Jacques Whitford

FINAL REPORT

Review of International Best Practices of Environmental Surveillance for Energy-From-Waste Facilities

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Review of International Best Practices of Environmental Surveillance for Energy-From-Waste Facilities

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STUDY SUMMARY

INTRODUCTION

Jacques Whitford Limited was retained by Durham Region to conduct a review of international best practices of environmental surveillance being undertaken at Energy-From-Waste (EFW) facilities. This study was specifically designed to address a motion made at the Durham Regional Council meeting on Wednesday, May 28th, 2008, which was carried and states in part:

"g) i) THAT staff review the best practices of environmental monitoring programs which include environmental surveillance, health surveys, biological monitoring, health studies, and any other pertinent studies as determined through the review and consultation regarding environmental monitoring programs; and

ii) THAT an environmental monitoring program be developed based on best practices which will provide baseline information and ongoing studies during the life cycle of the facility";

This project was completed in conjunction with the Durham/York Residual Waste Study, which is being completed to obtain approval to construct an EFW facility in the Municipality of Clarington, Ontario.

The focus of this study was to review environmental surveillance programs at similar facilities around the world and to recommend an appropriate level of environmental surveillance for the proposed EFW facility. This was achieved through a three pillar study approach involving - a systematic review of the scientific literature, a grey literature review and by interviewing international experts in the field of incineration environmental surveillance. The findings of each stage of the process were documented and then summarized by Country.

The objective of the Study Team is as follows:

"The consultant's recommended option for an environmental surveillance program for the proposed Durham/York Residual EFW facility will be based on the fundamental tenant that the program must ensure the protection of public and environmental health."

A multidisciplinary team of professionals were assembled to undertake this study and an independent peer review of the study by Dr. Lesbia Smith was commissioned by the Region of Durham.

The consultant's recommended environmental surveillance program will ensure the protection of human and environmental health during the operation of the proposed EFW facility. In addition, recommendations for what would trigger a more resource intensive surveillance program have been included.

KEY STUDY TERMINOLOGY

Surveillance is a continuous and systematic process of collection, analysis, interpretation, and dissemination of descriptive information for monitoring health problems (Rothman and Greenland, 1998). ***Monitoring*** is the intermittent performance and analysis of routine measurements, aimed at detecting changes in the environment or health status of the population (Last, 2000). Surveillance is distinguished from monitoring by the fact that it is continuous and ongoing, whereas monitoring is intermittent or episodic. The hierarchy of environmental surveillance is provided in Figure 1.

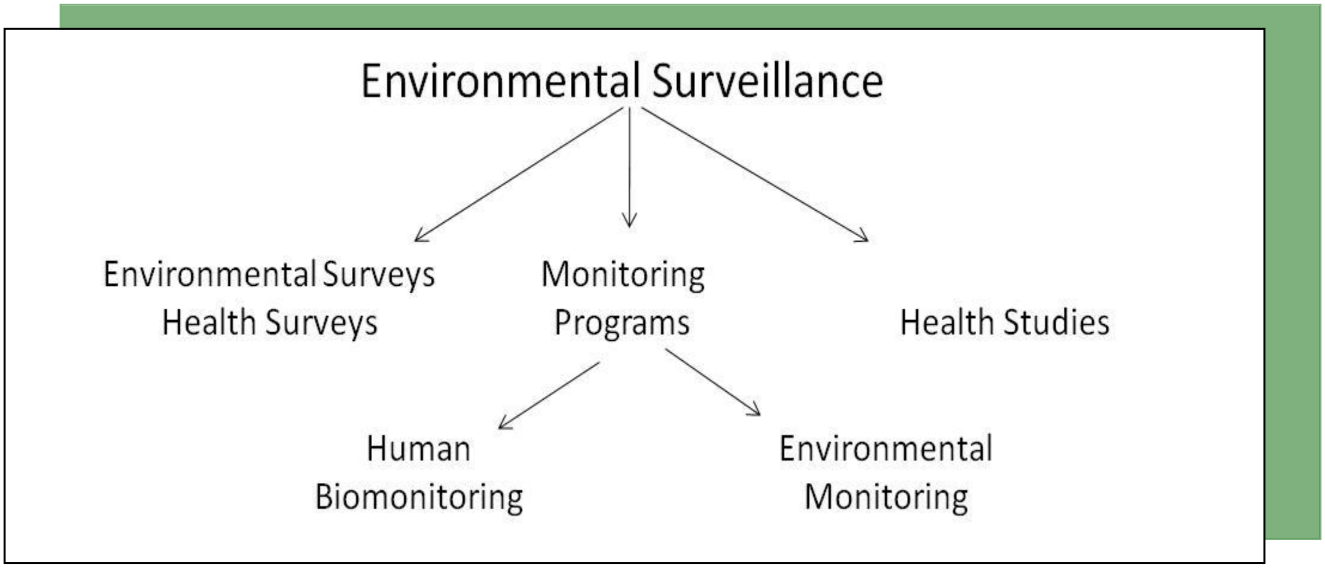


Figure 1. Environmental Surveillance Hierarchy

The following are brief descriptions of the key study terminology:

Environmental surveillance is a broad topic under which a wide range of information can be collected on emissions data, dispersion modeling, and the monitoring of air, water, soil, vegetation, wildlife and humans.

Environmental survey is an observational study of the ecosystem and its physical components to evaluate potential stressors on the environment (UN FAO, 1990). These surveys are also often referred as biophysical surveys and do not involve sampling or sacrificing flora or fauna, rather they are observational.

Health surveys collect information from participants about their health, habits and life circumstances through a variety of means, including through interviews (conducted in person or over the phone), or by self-administered questionnaires (WHO, 2008). They are often used to provide information on the health status of communities and estimates of health determinants.

Health studies differ from surveillance and monitoring programs in that they seek to identify the relationship between individual characteristics and the occurrence of disease or outcome.

Environmental monitoring involves the testing of media of ecosystem components such as soil, water, air, vegetation and fauna (*e.g.,* fish, small mammals, and birds). Stack testing of facilities emissions (whether periodic or continuous) is also considered environmental monitoring.

Human biological monitoring, more commonly known as human biomonitoring (HBM), is the measurement of specific substances in the human body, usually through the analysis of blood, urine, breast milk and tissue samples.

This study reviews best practices of environmental surveillance related to EFW facilities. However, the scientific literature on environmental surveillance options does not always distinguish between EFW and non-EFW facilities; therefore the search was appropriately widened to include all manner of incineration facilities. The Study Team distinguished between the types of incineration facilities that were studied by the researchers (e.g., municipal solid waste, hazardous waste or medical waste) throughout the report. The importance of this distinction is that the feedstock (material going into the process) contains different levels of chemicals in the material that was being incinerated.

In addition, the Study Team felt that it was important to distinguish between facilities that were built and operated with modern pollution control technology, from older facilities that may have emitted higher concentrations of chemicals than would be allowed by regulation in Ontario today.

Those facilities that were operating prior to the late 1990s were considered "older" facilities in this review as they generally emitted higher concentrations of chemicals (e.g. dioxins and furans), into the environment than would currently be allowed. It was also noted that several studies published after the late 1990s included an assessment of older facilities. The environmental surveillance programs in place for these facilities were deemed relevant to this study, but caution was applied when interpreting their findings and their applicability to the type of pollution control technology and emission standards that would be adopted for the Durham/York EFW facility.

SYSTEMATIC SCIENTIFIC LITERATURE REVIEW

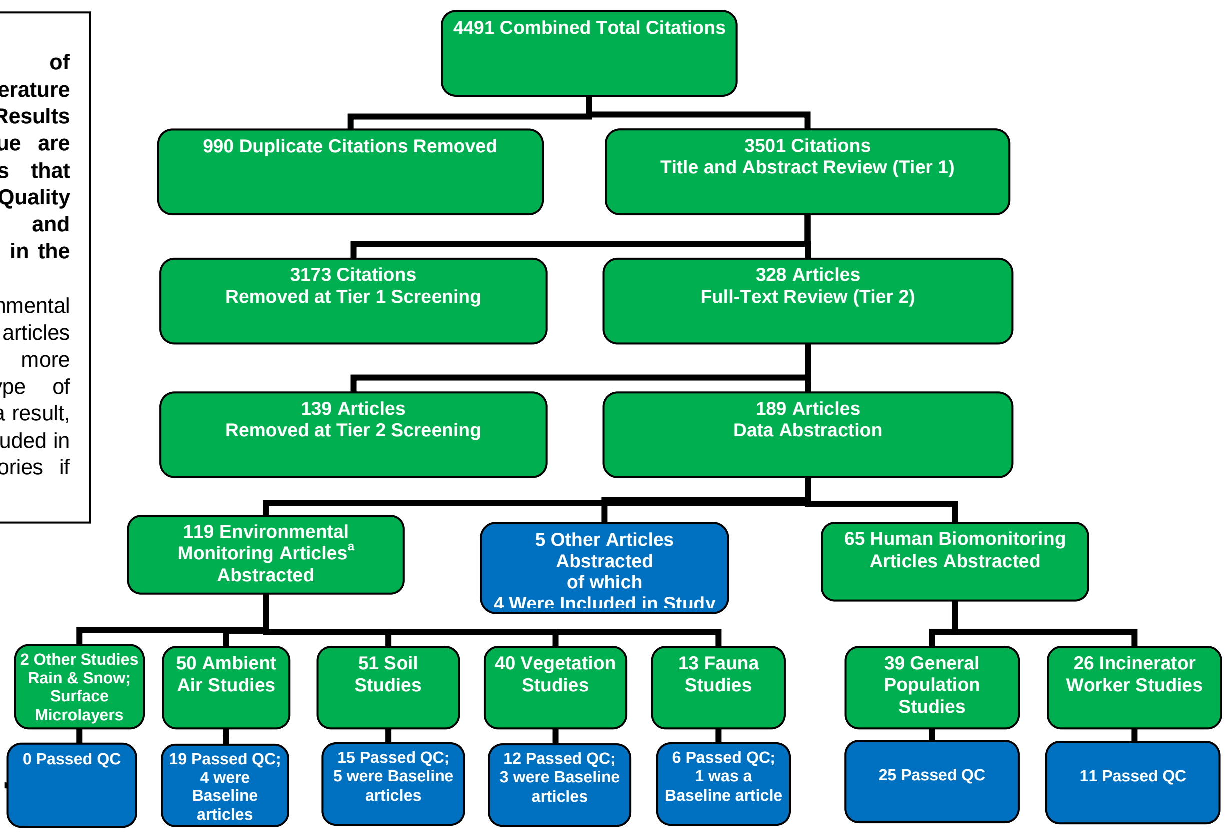
The objective of the systematic scientific literature review was to identify relevant English-language literature on the current practices employed in EFW realated environmental surveillance programs around the world, with a publication date of January 1, 1990 or later.

The systematic literature review was modelled after the Cochrane Handbook for Systematic Reviews of Interventions (Cochrane Collaboration, 2008). Cochrane reviews adhere to the principle that "science is cumulative" and by considering the available evidence, decisions can be made that reflect the best science available.

Articles Retrieved in the Systematic Literature Review

The literature search identified a total of 4,491 citations. After duplicates were removed, and screening was completed, 189 articles were retained for data abstraction and quality assessment. Sixty-six articles were categorized as human biomonitoring studies, and 119 as environmental monitoring studies. An additional 5 were categorized as "Other" because the study focus was not necessarily the description of a specific monitoring program, but the content was nevertheless relevant to the review. After the quality assessment framework was applied, 25 human biomonitoring articles of residential exposure and 59 environmental monitoring articles remained for inclusion in the study (Figure 2).

Figure 2. Summary of Scientific Literature Review Results (boxes in blue are those studies that passed Quality Assessment and were included in the review)
Note: [a] Environmental monitoring articles often involved more than one type of media and as a result, studies are included in multiple categories if appropriate.



Results of the Systematic Literature Review

Baseline Studies Conducted Prior to Operation of an Incineration Facility

Eleven of the scientific articles retrieved and included in this study were environmental baseline programs, conducted prior to an incineration facility becoming operational. These environmental baseline programs typically involved the sampling of a number of chemicals in various environmental media. The sample locations were selected through review of atmospheric dispersion modelling results, which provide the predicted zone of influence of a facility's emissions (typically within 1 km of the facility). Baseline sample medium included ambient air, soil, vegetation, and bovine milk. The authors emphasized the importance of collection of an environmental baseline, so that samples collected and analyzed in the future could be benchmarked against pre-operational conditions.

> ***Study Team Finding***
> *These studies illustrate the importance of conducting chemical baseline investigations prior to commissioning of an EFW facility. It forms the benchmark against which any samples collected during the facility's operation would be evaluated.*
>
> *Durham and York Regions are in the process of finalizing an environmental baseline study, similar to those reported in the literature.*

Ambient Air Monitoring Studies

In general, high volume air samplers were sited downwind of a facility and within its modelled chemical depositional range. In many studies, a control location was set up in an area predicted to be outside of the zone of influence of the incinerator. This allowed the researchers to compare the ground level concentrations of chemicals within the zone of influence of the facility to background conditions. Dioxins and furans, trace metals and volatile organic compounds (VOCs) were the most commonly measured chemicals.

> ***Study Team Finding***
> It is concluded from the scientific literature that an ongoing ambient air monitoring program would not be required for the proposed Durham/York EFW facility to ensure the protection of human or environmental health.
>
> This conclusion was reached on the basis that no correlation was found between chemical concentrations in ambient air and stack emissions from facilities that employ modern pollution control technology.

The literature review determined that facilities that had upgraded or modern pollution control technology do not appear to be a significant source of chemicals detected in ambient air surrounding the incineration facility. However, older MWI facilities or hazardous waste facilities appear to in some cases have been a significant contributor to ambient levels of chemicals in the air surrounding these facilities.

The zone of potential influence of the facilities studied appears to be no greater than 2 km from the stack, with the majority of research focused in areas less than 0.5 km from the facilities. Baseline or control locations formed a critical part in all of the studies.

Soil Quality Monitoring Studies

The soil monitoring programs included the analysis of chemicals in multiple samples, predominately located within the depositional zones of a waste incinerator and a comparison to either baseline or background samples. In general, soil was usually collected from the upper 5 centimetres of the soil column. The most common chemicals analyzed were dioxin and furans and metals.

Study Team Finding

It is concluded from the scientific literature that an ongoing soil monitoring program would not be required for the proposed Durham/York EFW facility to ensure the protection of human or environmental health.

This conclusion was reached on the basis that a modern incineration facility that employs current pollution control technology should not impact local soil quality.

A number of articles published on older facilities, without modern pollution control technologies, reported a significant distance-decay effect associated with soil chemical concentrations and incineration facilities. However, in most cases contributions by other pollution sources could not be ruled out. There were also a number of scientific papers that showed no impact to local soil quality as a result of incinerator emissions.

Perhaps the most significant finding was that soil sampling programs surrounding older facilities were most effective when samples were collected within close proximity (<1km) of facilities. While a soil monitoring program may be beneficial in addressing public concern related to EFW facility emissions, a modern EFW facility equipped with the latest pollution control devices would be unlikely to have measurable changes in chemical concentrations in soils surrounding the facility. This is also supported by the deposition modeling that was completed in the Durham/York Residual Waste Study Generic Risk Assessment, where soil loading concentrations at the maximum deposition location were predicted to be less than 1% of background levels.

Vegetation Monitoring Programs

In general, the vegetation monitoring programs included the analysis of chemicals in multiple samples, predominately located within the depositional zones of an incinerator and a comparison to either baseline or background samples. The type of vegetation sampled varied from study to study and was heavily dependent on the type of vegetation around the site. The most common chemical concentrations quantified in vegetation samples were metals, dioxin and furans, and PCBs.

In summary, vegetation monitoring programs further support the hypothesis that incinerators with poor pollution abatement technologies tend to have a more significant effect on chemical concentrations in environmental media. In addition the vegetation monitoring programs also found that there is a distance decay effect associated with chemical concentrations. It was also determined that samples, if collected, should be taken within 1 km of a facility and only provide a good indicator of short-term chemical deposition from an EFW facility.

Study Team Finding

It is concluded from the scientific literature that an ongoing vegetation monitoring program would not be required for the proposed Durham/York EFW facility to ensure the protection of human or environmental health.

This conclusion was reached on the basis that a modern incinerator that employs current pollution control technology should not impact local vegetation quality.

Agricultural Products Monitoring Programs

There were a limited number of studies in the scientific literature that attempted to study the relationship between incineration facilities and the potential effects on agricultural products (e.g., beef, dairy, eggs, and pork). The most common chemical concentrations quantified in samples were metals and dioxins and furans.

The agricultural product studies were conducted on facilities with older pollution control technology and may not be representative of levels that may be found surrounding facilities built after the late 1990s. The media sampled were agricultural meat (poultry or beef), dairy products, and chicken. In one study, duck eggs were collected from close proximity to an incinerator. Meat, dairy and egg samples were collected directly from farms located within the depositional ranges of a waste incinerator and directly transported to the laboratory for chemical analysis.

The majority of the research studies were unable to find significant chemical concentrations in agricultural samples at levels that would adversely affect human health (consumption of the products) and ecological health. In the studies that reported significantly elevated chemical concentrations in agricultural products, the age of the incinerator and insufficient pollution control technologies were factors, which is a reoccurring trend in the environmental monitoring programs reviewed.

Study Team Finding

These studies indicate that the age of the incineration facility may affect the chemical concentrations in some agricultural products.

The study surrounding a modern incineration facility showed no significant increase of chemicals in numerous agricultural products.

Studies also indicated that samples should be taken in close proximity to the facility.

Human Biomonitoring of Residents

Twenty-five articles that involved human biomonitoring of residents living in the vicinity of an incineration facility passed the quality assurance check and were included in the study. Where multiple articles related to the same study, they were grouped and discussed as a comprehensive study.

In summary, the results of the systematic review of the scientific published literature indicate that there is not a significant relationship between exposure to chemical emissions from incinerator and measured chemical levels in human media such as blood, urine, breast milk and hair. With regard to dioxins and furans, the most commonly referenced chemical assessed in the studies, authors noted occasional differences in individual dioxin and furan congeners and measured samples. Congener analysis can be important as it may be possible to correlate a particular individual congener emitted from an EFW facility to those found in exposed residents. However, no two congeners are the same, and some are more or less toxic than others. The toxic equivalent (TEQ) is thus a useful measure, as it provides a single, cumulative number based on the relative toxicity of each congener.

Study Team Finding

It is concluded from the scientific literature that an ongoing human monitoring program would not be required for the proposed Durham/York EFW facility to ensure the protection of human or environmental health.

This conclusion was reached on the basis that there was no correlation between chemicals emitted from modern MWI facilities and those measured in the human biomonitoring programs.

The only study to identify significantly elevated dioxin and furan TEQ levels in humans were Fierens et al., 2003; Fierens et al., 2007, which identified this trend in residents of a rural area containing an older municipal waste incinerator, which for nearly 20 years emitted dioxins at levels 500 times greater than the current emissions limit in the European Union or the Ontario Guideline A-7 allowable limits. These emissions levels resulted in high levels of dioxins and furans in the local environment, which was then transferred to the local residents in the form of dietary intake, as this rural population ingested a large amount of local dairy and livestock.

GREY LITERATURE REVIEW

While the scientific literature review brought forth considerable information, most of which originates in the academic community, it was anticipated that a full and complete review of the topic would necessitate a review of the grey literature – that is, literature not produced by bodies whose sole objective is publishing or that is not indexed in a scientific database. Findings included technical reports, government publications, regulations and legislation, conference proceedings, presentations, or unfinished “working reports”.

Seven documents had information that directly pertained to environmental monitoring programs. Of these, five documents described programs that were in the vicinity of a waste incineration facility. The most common environmental sample was ambient air followed by soil and vegetation and finally fauna. The chemicals of concern that were frequently studied were dioxin and furan concentrations, PCBs, and metals.

Five grey literature articles that reported on the results of human biomonitoring surrounding incineration facilities were included in this study. Age groups studied ranged from newborns to the elderly (up to age 65). Sample tissues collected included urine, blood, serum and hair. In the studies that assessed newborns and expectant mothers, breast milk and umbilical cord blood were collected. Chemicals varied by study, but included dioxins and furans, metals, PAHs, and PCBs.

The results of the grey literature review were consistent with the findings of the systematic review of the scientific published literature. The fact that both the findings of the published and unpublished literature were similar is an encouraging result. The Study Team believes it is unlikely that additional information may have been missed during this review, which would alter our findings or conclusions.

Grey Literature on National Human Biomonitoring Programs

Throughout the grey literature and external contact review, it was observed by the review team that many countries have implemented a national human biomonitoring program. These programs are aimed at understanding chemical concentrations in the general human population. This is not particularly associated with any one industry, but rather to examine the overall population level of exposure to environmental contaminants.

Studies reviewed included the Canadian Health Measures Survey (CHMS), the Canadian Maternal-Infant Research on Environmental Chemicals (MIREC) study, the United States National Health and Nutrition Examination Survey (NHANES), and the European Union Expert Team to Support Biomonitoring in Europe (ESBIO).

EXTERNAL CONTACT INTERVIEWS

Many governmental or legislated environmental surveillance programs are not published in the scientific literature, relying instead on internal or external governmental websites and documents with limited dissemination. In order to obtain a more holistic view of the practices of environmental surveillance programs associated with the energy-from-waste industry, it was essential to contact individuals in this field of work, who are directly involved with these programs.

Although many valuable contacts were made, and interviews conducted during this phase of the project, unfortunately not all of those who were contacted by the reviewers responded to our repeated inquiries. However, the reviewers believe that the information gained from respondents was sufficient to support the study findings and conclusions.

The Study Team was fortunate to be able to interview four academic / experts in the field of EFW environmental surveillance, five government employees, and two owners/operators of European Union EFW facilities. The discussions and responses to questionnaires served to reiterate the various practices of environmental surveillance surrounding incineration facilities around the world.

With the exception of Portugal, the majority of countries and regulatory bodies mandate stack testing and monitoring of chemical parameters at incineration facilities. The primary driver behind this being the belief that air dispersion modelling and human health risk assessment, in combination with stack testing/monitoring are sufficient to ensure the protection of human and environmental health. Portugal appears to be the only country that commonly mandates a more resource intensive environmental surveillance program, often in the form of human and environmental biomonitoring.

SUMMARY OF GLOBAL ENVIRONMENAL SURVEILLANCE REQUIREMENTS FOR INCINERATION FACILITIES

Though it is difficult to make generalized worldwide claims as to the practices of environmental surveillance around incineration facilities, some notable trends are apparent.

- Most countries were identified to govern incineration facilities similarly to the Canadian approach – at the regional/provincial/state level.
- In almost all cases, prior to project approval an environmental assessment is required to determine whether the facility could adversely impact air quality, human and environmental health.
- The majority of facilities around the world conduct only stack monitoring programs, with the exception of Portugal where environmental monitoring and human biomonitoring programs may be mandated under the operating permits of individual facilities (Table 1).

This review found that older incineration facilities and/or those with less advanced or no air pollution control technology may have impacted the environment immediately surrounding the facility. The study results indicate that a modern incineration facility, such as the one being proposed by the Regions of Durham and York, that employ maximum achievable control technology for air pollution, would be unlikely to impact the health of local residents or the environment.

Table 1. Summary of environmental surveillance practices on a country-by-country basis for incineration. An X was used to denote a government requirement – either legislated or as part of individual facility operating requirements.

Country	Municipal Waste Incinerators							
	Continuous Stack Monitoring	Periodic Stack Testing	Periodic Ambient Air Monitoring	Continuous Ambient Air Monitoring	Soil Monitoring	Vegetation Monitoring	Agricultural Product Monitoring	Human Biomonitoring
Canada	X	X						
Ontario	X	X			X			
United States	X	X						
European Union	X	X						
Portugal	X	X	At some locations	At some locations				At some locations
Spain	X	X	At some locations	At some locations				
Belgium	X	X						
Germany	X	X						
Italy	X	X	At some locations	At some locations				
Sweden	X	X						
Taiwan	X	X						
Korea	X	X						
Japan	X	X						
Hong Kong	x	X						

STUDY TEAM RECOMMENDATIONS FOR ENVIRONMENTAL SURVEILLANCE OF THE DURHAM/YORK EFW FACILITY

Globally the government legislative requirement for environmental surveillance of incineration facilities is continuous and periodic testing of chemical emissions at the stack. The adoption of this level of surveillance for a modern incineration facility, that would incorporate maximum achievable pollution control technology (MACT), was deemed by the Study Team to be scientifically justified to ensure the protection of both human and environmental health. Continuous stack monitoring of a limited number of chemicals (e.g., NO_x and SO_2) are used as surrogates for other chemical parameters between periodic manual stack testing events. This level of environmental surveillance ensures that the facility is operating within its purported emissions control limits for all chemicals. This level of environmental surveillance ensures that the facility is operating within its purported emissions control limits for all chemicals.

In the event that continuous stack monitoring highlights an issue with the facility emissions in real-time, the source of the problem is identified. If the problem is combustion related, the operators adjust combustion parameters to correct the issue in real-time. If the problem is not combustion related, then it is possible that the unit where the problem lies can be shut-down until the problem is rectified. Exceedances of emissions limits would be required to be reported to the Ontario Ministry of the Environment (MOE). It would be the responsibility of the MOE to verify that proper steps have been taken to rectify the issue with facility operators.

The Study Team originally envisioned the inclusion of an initial cost estimate for each of the environmental surveillance options. However, it became apparent during the review process that inclusion of costs could potentially bias the selection of a scientifically-based optimal option for the protection of public and environmental health. Therefore, costs were excluded from consideration in this review and can be provided once a preferred option is adopted by Durham Regional Council.

Through the grey literature review and external contact survey, another key component to environmental surveillance of incineration facilities was reported to be the establishment of an independent facility-specific oversight committee. In 2008, as part of the Durham/York Residual Waste Study a Site Liaison Committee (SLC) was established to review and provide input on site specific studies related to the study of the proposed EFW facility. A new committee will be established once the facility is operational.

Regardless of which environmental surveillance option is ultimately put in place, it is proposed by the Study Team that this committee be charged, in part, with review of any environmental surveillance program being undertaken for the Durham/York EFW facility. This would ensure public participation in the environmental surveillance program and evaluation of its efficacy in protecting public and environmental health.

Supported by the scientific findings of our review, the Study Team recommends that the following three environmental surveillance options be considered for implementation by the Regions of Durham and York for their proposed EFW facility.

Option 1 – Chemical Emissions Stack Monitoring and Testing

Option 1 a) Compliance with Ontario Guideline A-7 Combustion and Air Pollution Control Requirements for New Municipal Waste Incinerators

This represents the minimum level of environmental surveillance and monitoring to which the EFW facility must commit. This will ensure the protection of the surrounding environment and conform to the regulatory requirements associated with the operation of such a facility in Ontario. Guideline A-7 stipulates the combustion and air pollution emissions and monitoring requirements for municipal waste incinerators operating in Ontario and forms the basis of issuing the Certificate of Approval (CofA) by the MOE.

Guideline A-7 sets out fixed emission limits for nine (9) parameters: particulate matter, cadmium, lead, mercury, dioxins and furans, hydrochloric acid, sulphur dioxide, nitrogen oxides and organic matter. The facility is required to prove compliance with the standards within six months of start-up under maximum operating feed rates, and thereafter, at a minimum of once a year. This is accomplished via annual emissions sampling at the stack, under maximum operating feed rates, in accordance with the methods and procedures documented in the Ontario Source Testing Code (Procedure A-1-1).

Continuous stack monitoring of the combustion gases CO, O_2, NO_x, HCl and SO_2 should be considered, with at a minimum annual source testing of additional contaminants such as dioxins and furans, VOCs, particulate matter, metals and PAHs. These requirements would be negotiated with the MOE and implemented through inclusion of conditions in the facility's CofA (Air).

This level of environmental surveillance allows for early detection of any potential upset conditions, which can be corrected by facility operators or result in shut-down if stack emissions are above those permitted in the CofA. A robust, continuous stack monitoring of combustion gases, in combination with annual source testing would ensure that chemical concentrations used in the risk assessment are being achieved. This level of environmental surveillance was found to be in place at all incineration facilities in the EU, US and Canada.

Option 1b) Establishment of More Stringent Stack Chemical Emissions Standards than Provided in Guideline A-7

Based on a motion passed at Durham Regional Council, the Request for Proposal (RFP) for vendors stipulates that the lower of the Ontario Guideline A-7 or EU Directive chemical emissions standards will form the basis for the proposed CofA governing emissions limits for the facility (Table 2). This level of environmental surveillance would provide an additional level of protection for humans and the environment surrounding the proposed facility.

Table 2. The Regions' air emissions criteria based upon the MOE and EU air emissions requirements

Pollutant	Units (1)	Ontario Guideline A-7	EU Directive 2000/76/EC EU Limits	YD EFW Stack Emission Limits	Measurement Basis (see Notes)
Total Particulate Matter	mg/Rm^3	17	9	**9**	(2)
Sulphur Dioxide (SO_2)	mg/Rm^3	56	46	**35**	(3)
Hydrogen Chloride (HCl)	mg/Rm^3	27	9	**9**	(4)
Hydrogen Fluoride (HF)	mg/Rm^3	Not Specified	0.92	**0.92**	(4)
Nitrogen Oxides (NO_X)	mg/Rm^3	207	183	**180**	(4)
Carbon Monoxide (CO)	mg/Rm^3	Not Specified	46	**45**	(4)
Mercury (Hg)	$\mu g/Rm^3$	20	46	**15**	(2)
Cadmium (Cd)	$\mu g/Rm^3$	14	Not Specified	**7**	(2)
Cadmium + Thallium (Cd + Th)	$\mu g/Rm^3$	Not Specified	46	**46**	(2)
Lead (Pb)	$\mu g/Rm^3$	142	Not Specified	**50**	(2)
Sum of (As, Ni, Co, Pb, Cr, Cu, V, Mn, Sb)	$\mu g/Rm^3$	Not Specified	460	**460**	(2)
Dioxins	pg/Rm^3	80	92	**60**	(2)
Organic Matter (as CH_4)	mg/Rm^3	66	Not Specified	**49**	(2)

NOTES:
(1) = All units corrected to 11% O_2 and adjusted to Reference Temperature and Pressure, mg/Rm^3 = Milligrams per Reference Cubic Metre (25^0 C, 101.3 kPa), $\mu g/Rm^3$ = Micrograms per Reference Cubic Metre (25^0 C, 101.3 kPa), Pg/Rm^3 = Picograms per Reference Cubic Metre (25^0 C, 101.3 kPa), (2) Calculated as the

arithmetic average of 3 stack tests conducted in accordance with standard methods, (3) Calculated as the geometric average of 24 hours of data from a continuous emission monitoring system, (4) Calculated as the arithmetic average of 24 hours of data from a continuous emission monitoring system

Option 1c) Inclusion of New Stack Sampling Technology for Dioxins and Furans not Routinely Implemented in Ontario EFW or Incineration Facilities

Stack emissions of dioxins and furans have historically been measured by periodic stack testing (along with other contaminants of concern). Since there is a heightened public awareness of dioxin and furan emissions from EFW facilities, a considerable amount of research has been focused on development of methods for more frequent sample collection and analysis of stack emissions of dioxins and furans.

Technology now exists for continuous sampling (not monitoring) of dioxins and furans in stacks. In-stack dioxins and furans concentrations are sampled for a period of time at regular intervals (e.g., once a month, quarterly, or semi-annually). The sample media is removed, sent for laboratory analysis of dioxins and furans and replaced in the stack. The advantage of this technology is that more frequent sampling of dioxins and furans can be achieved for an EFW facility.

Based on a motion passed at Durham Regional Council, the Request for Proposal (RFP) for vendors stipulates that some form of continuous dioxins and furans sampling and periodic analysis must be included in the design and operation of the proposed EFW facility.

Although this technology was not included as part of this review, the Study Team beleives that it would provide additional information to ensure that dioxins and furans concentrations used in the risk assessment are being achieved.

ADDITIONAL LEVELS OF ENVIRONMENTAL SURVEILLANCE NOT RECOMMENDED BY THE STUDY TEAM

Although the Study Team concluded that the most scientifically defensible environmental surveillance option to ensure the protection of public and environmental health was stack monitoring and testing (Option 1), there are additional environmental surveillance options being employed around the world at individual incineration facilities.

These options include:

- Option 2: ambient air monitoring;
- Option 3: environmental monitoring (soil, vegetation, agricultural products); and,
- Option 4: human biomonitoring.

During the review, the Study Team concluded that a modern municipal waste incinerator that would employ the maximum achievable pollution control technology (MACT), would not significantly increase contaminant levels in the environment. This was supported by the scientific literature, the grey literature and the external contact interview process.

Studies that reported significant increases of pollutants in environmental media were predominately conducted on older incineration facilities, and in many cases on those facilities that had different feedstock (e.g., hazardous waste) than would be permitted for the municipal waste incinerator proposed for Durham/York. To date, human biomonitoring studies have not reported a statistical increase in human tissue chemical concentrations as a result of exposure to a municipal waste incinerator.

The impetus for these environmental surveillance programs was reported to be a combination of academic interest and/or a heightened level of public concern surrounding an individual facility. Scientific methods used to gauge public concern surrounding these facilities were not reported, and did not appear to have been carried out by the authors or government officials. The Study Team acknowledges that these are indeed valid societal reasons for policy makers to trigger additional levels of environmental surveillance. However, we believe that it was not appropriate for the Study Team to presuppose or gauge the level of public concern surrounding the Durham/York proposed EFW facility.

If based on perceived public concern, policy makers believe that an additional level of environmental surveillance is warranted, we recommend that this be supported through scientific means such as a polling exercise. Experts in this area of study should be retained by the Regions to develop an appropriate tool for such an assignment.

Although not recommended for implementation, the Study Team has provided a range of additional surveillance options, with each successive level also intended to include all preceding options. Recommendations for what would trigger a more resource intensive surveillance program have been also been included for consideration.

CONCLUSIONS OF THE STUDY

A considerable amount of information on best practices in environmental surveillance for incineration facilities from around the world was obtained through a systematic literature review (Section 3), grey literature search (Section 4) and external contact interview process (Section 5). The legislated or government mandated requirements of environmental surveillance were summarized in Section 6.

Overall, there was a great deal of consistency between the environmental surveillance options (Figure 2-1) reported in the scientific literature, the grey literature and through external contact interviews with experts in the field. On this basis, the Study Team believes that it is unlikely that additional information may have been missed during this review, which would alter our findings, conclusions or recommendations.

Ultimately the review determined that a modern municipal waste incinerator that would employ the maximum achievable pollution control technology (MACT) would not significantly increase contaminant levels in the environment. This was supported by the scientific literature, the grey literature and the external contact interview process.

Therefore, the most appropriate and scientifically justified option for environmental surveillance of an EFW facility to be located in the Region of Durham would involve continuous and periodic stack testing of chemical emissions (Option 1). This environmental surveillance option was also found to be the most prevalent method of ensuring public and environmental health protection in Canada, countries of the European Union, and the United States.

In addition to meeting the minimum stack emissions requirements laid out in Guideline A-7, the Study Team supports the decision of Durham Regional Council to:

- Adopt the more stringent of the Guideline A-7 and EU Directive chemical emissions standards; and,
- Implement an in-stack dioxins and furans sampling technology.

These measures go beyond any requirements that would have been derived from our review.

Another key component to environmental surveillance of incineration facilities was reported to be the establishment of an independent facility-specific oversight committee. It is proposed by the Study Team that such a committee be formed and charged, in part, with review of any environmental surveillance program being undertaken for the Durham/York EFW facility. This would in no way remove the onus of facility regulation from the Ontario Ministry of the Environment. Rather, it would ensure public participation in the environmental surveillance program and evaluation of its efficacy in protecting public and environmental health.

The findings of the review do not justify implementation of ambient air monitoring (Option 2) or environmental monitoring (soil, vegetation, agricultural products) (Option 3). In addition, we would strongly recommend that human biomonitoring (Option 4) not be adopted for the proposed Durham/York EFW facility. The Study Team does not believe that there would be any trigger that would justify the need for this level of environmental surveillance.

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List of Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
Al	Aluminum
As	Arsenic
Be	Beryllium
BWI	Biological waste incinerator
Cd	Cadmium
CCME	Canadian Council of Ministers of the Environment
CHMS	Canadian Health Measures Survey
CDC	Centers for Disease Control
C of A	Certificate of Approval
CWTC	Chemical Waste Treatment Center
Cr	Chromium
CEC	Commission of European Communities
Cu	Copper
DPA/EHBA	Database of Published Articles on European Human Biomonitoring Activities
EFW	Energy from Waste
EQS	Environmental Quality Standard
EU	European Union
ESBIO	Expert Team to Support Biomonitoring in Europe
GC/MS	Gas chromatograph/mass spectrometer
GerES	German Environmental Survey
HWI	Hazardous waste incinerator
HRGC/HRMS	High resolution gas chromatograph/high-resolution mass spectrometer
HBM	Human Biomonitoring
ICP/MS	Inductively coupled plasma mass spectrometry
IDAD	Institute for Environment and Development
LIPOR	Intermunicipal Waste Management of Greater Porto
I-TEQ	International Toxic Equivalency Factor
JWMG	Joint Waste Management Group
Pb	Lead
Mn	Manganese
MIREC	Maternal-Infant Research on Environmental Chemicals
MACT	Maximum achievable control technology
Hg	Mercury
MOE	Ministry of the Environment
MWI/MSWI	Municipal waste incinerator/ Municipal Solid Waste Incinerators
NHANES	National Health and Nutritional Examination Survey

NHES	National Health Examination Surveys
NIOSH	National Institute for Occupational Safety and Health
Ni	Nickel
NGO	Non-Governmental Organizations
PM	Particulate matter
PCP	Pentachlorophenol
PBDE	Polybrominated diphenyl ethers
PCB	Polychlorinated biphenyl
PCDD/F	Polychlorinated dibenzo-dioxin/furan
PCN	Polychlorinated naphthalene
PAH	Polycyclic aromatic hydrocarbons
PUF	Polyurethane foam
QA	Quality Assurance
QC	Quality Control
Si	Silver
Tl	Thallium
Sn	Tin
US EPA	United States Environmental Protection Agency
V	Vanadium
VOC	Volatile organic chemicals
WTEF	Waste to Energy Facility
Zn	Zinc

REPORT

1.0 OVERVIEW

Jacques Whitford Limited was retained by Durham Region to conduct a review of international best practices of environmental surveillance being undertaken at Energy-From-Waste (EFW) facilities. This study was specifically designed to address a motion made at the Durham Regional Council meeting on Wednesday, May 28th, 2008, which was carried and states in part:

> *"g) i) THAT staff review the best practices of environmental monitoring programs which include environmental surveillance, health surveys, biological monitoring, health studies, and any other pertinent studies as determined through the review and consultation regarding environmental monitoring programs; and*
>
> *ii) THAT an environmental monitoring program be developed based on best practices which will provide baseline information and ongoing studies during the life cycle of the facility";*

This project was completed in conjunction with the Durham/York Residual Waste Study, which is focused on obtaining Individual Environmental Assessment (EA) approval to construct an EFW facility from the Ontario Ministry of the Environment (MOE). The EA must demonstrate through the air modeling and risk assessment studies that there will not be an unacceptable risk to either humans or the environment, as a result of chemical emissions from the proposed EFW facility.

The focus of this study was to review environmental surveillance programs at similar facilities around the world and to recommend an appropriate level of environmental surveillance for the proposed EFW facility. This was achieved through a three pillar study approach involving - a systematic review of the scientific literature, a grey literature review and by interviewing international experts in the field of environmental surveillance. The findings of each stage of the process were documented and then summarized by country.

The objective of the Study Team, as stated in the Study Protocol, is as follows:

> *"The consultant's recommended option for an environmental surveillance program for the proposed Durham/York Residual EFW facility will be based on the fundamental tenant that the program must ensure the protection of public and environmental health."*

1.1 Study Methodology

This study covers a review of environmental surveillance and includes both environmental and human health monitoring. Environmental surveillance is an all-encompassing term, while human health and environmental monitoring are considered components of environmental surveillance programs. Human health monitoring can include programs such as health surveys, health studies and biological monitoring (i.e. human biomonitoring), which typically involves the collection of human samples (i.e. blood, urine, etc.) for chemicals and associated by-products. Environmental monitoring, on the other hand, typically involves the sampling of environmental media; examples include soil, air, water or biota (*e.g.*, fish, small mammals, and vegetation).

Figure 1-1 provides a general outline and overview of the study that was conducted in two stages. Stage 1 was the development of the Study Protocol (Jacques Whitford, 2008), which guided the conduct of the Study Team throughout the project and ensured that scientifically sound and defensible methods for the various tasks were followed. The Study Protocol (Appendix H) was reviewed by an independent third party peer reviewer. Stage 2 of the project consisted of undertaking its implementation.

The systematic review of the scientific literature consisted primarily of three separate elements – the literature search strategy, the inclusion/exclusion criteria for the analysis of the search results, and the framework for documenting, evaluating and interpreting results. These three elements combined provided a transparent framework to support the consistent review of articles. Likewise, the protocol for securing information from external contacts ensured that consistent information was obtained without the need for repeated inquiries.

The grey literature search of environmental surveillance programs provided a solid foundation for the reviewers on which to build their review. Possessing this background knowledge also aided in informing the reviewers prior to conducting external contact interviews, such that the reviewers were able to maximize their ability to engage the interviewees and retrieve information relevant to the study objectives.

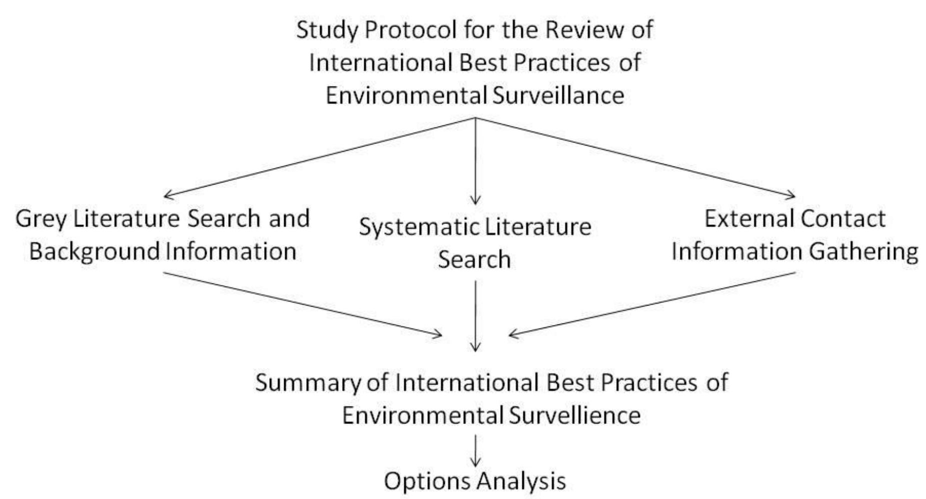

Figure 1-1 General Overview of Study Process

The information obtained through the three pillars of the study design culminated in a summary of EFW facility environmental surveillance practices by country. This information was then used to develop a series of options that could be considered for the development of a project-specific environmental surveillance program. The consultant's recommended environmental surveillance program was based on an appropriate and scientifically justified option that would ensure the protection of human and environmental health during the operation of an EFW facility in Ontario. In addition, recommendations for what would trigger a more resource intensive surveillance program have been included.

A multidisciplinary team of professionals was assembled to undertake this study and their curriculum vitae are included in Appendix I. An independent peer review of the study by Dr. Lesbia Smith was commissioned by the Region of Durham.

2.0 STUDY BACKGROUND AND KEY STUDY TERMINOLOGY

A thorough understanding of the basis upon which Project environmental approval is granted, is fundamental to the development of an environmental surveillance program. This section provides an overview to the Individual Environmental Assessment (EA) process that is being followed specifically for the Durham/York Residual Waste Study. Although this study is being conducted in parallel with, and will not form part of, the EA Study it is critical to understand the process when selecting an environmental surveillance option that would be protective of health and the environment during the operation of the EFW facility.

Key study terms and concepts in relation to the broad term environmental surveillance are also defined.

2.1 Ontario Individual Environmental Assessment and Technical Studies

In Ontario, EA is a planning and decision-making process that applies to projects that are subject to the Environmental Assessment Act (EAA), R.S.O. 1990, C.E. 18. The purpose of this Act is:

> *"…the betterment of the people of the whole or any part of Ontario by providing for the protection, conservation and wise management of the environment in Ontario"*

An EA assesses the potential effects of a project on the environment. It involves the comparison of alternatives, considering both advantages and disadvantages to the environment (natural, social, economic, cultural and built environments) and results in the identification of a preferred alternative.

The first step in the EA process is the submission of terms of reference (TOR) for approval by the Minister of the Environment (Minister). The initial planning stages for the Durham/York Residual Waste Study began in September of 2004. A considerable amount of technical work and public consultation, in the form of workshops and information sessions, was carried out to develop a draft TOR for this EA. The Approved TOR for the Durham/York Residual Waste Study was issued by the Minister on March 31, 2006. The TOR is the framework for how the EA Study is to be prepared and will be used as the benchmark for the Minister to review the EA.

The EA Study must follow the methodology set out in the TOR and generally addresses:

- The purpose of the undertaking;
- The rationale for the undertaking, the alternative methods of carrying out the undertaking, and the alternatives to the undertaking;
- A description of the environment that will be affected or that might reasonably be expected to be affected, directly or indirectly, the effects that will be caused or that might reasonably be expected to be caused to the environment;
- The actions necessary or that may reasonably be expected to be necessary to prevent, change, mitigate or remedy the effects upon or the effects that might reasonably be expected upon the environment, by the undertaking, the alternative methods of carrying out the undertaking and the alternatives to the undertaking;
- An evaluation of the advantages and disadvantages to the environment of the undertaking, the alternative methods of carrying out the undertaking and the alternatives to the undertaking resulting in the selection of the preferred undertaking; and,
- Consultation about the undertaking.

The Durham/York Residual Waste EA Study is very extensive and includes a number of technical component studies that address the potential effects of the project on the environment. Of particular interest to developing an appropriate environmental surveillance program are the site-specific air quality study and the site-specific human health and ecological risk assessment (HHERA). When the EA Study is submitted for Minister approval, there will be a requirement to demonstrate that chemical emissions to air from the facility will be lower than those prescribed in Ontario air quality regulations and that the levels would not pose an unacceptable risk to either people or the surrounding environment. Design, construction and operation of the facility could proceed only after the Minister is satisfied that this would be the case and approval has been issued.

2.1.1 Air Quality Assessment, Baseline Collection and Dispersion Modelling

The primary pathway for contaminants to reach human and ecological receptors from an EFW facility is through airborne dispersion and deposition of contaminants from the stack, which is equipped with air pollution control equipment.

In anticipation that this would be the primary route of exposure, an extensive year long baseline ambient air monitoring program was established at the preferred location. The collected baseline ambient air quality data will provide valuable information to assess the potential effects of the project on the existing ambient air quality levels of the area, and will provide the baseline to compare ambient levels of contaminants measured during future monitoring (if deemed necessary) once the EFW facility becomes operational.

For the EA Study, a team of air quality and dispersion modelling experts will undertake a site, and vendor-specific, study with the key objectives of:

- Providing data required to conduct the assessment of the potential environmental effects, including cumulative effects of the Project on air quality.
- Providing concentration and deposition data to the Human Health and Ecological Risk Assessment (HHERA) team to conduct their analysis.

The assessment of air quality effects related to the project will consist of the following elements:

- Compilation of emissions inventories of point and mobile sources for the Project and other existing sources;
- Assessment of baseline ambient air quality conditions for chemicals of potential concern (COPCs);
- Dispersion and deposition modelling of the Project to provide input to the HHERA, and to support the assessment of potential environmental effects, including cumulative effects, for the EA; and,
- Comparison of dispersion model predictions to Ontario ambient air quality criteria (AAQC), as well as evaluation of the incremental change in air quality associated with the Project emissions.

A number of chemicals of varying magnitudes may be emitted from an EFW facility. The intention of the air modelling exercise will be to provide a conservative, yet accurate, assessment of the chemical concentrations that will be experienced at ground-level as a result of the EFW facility emissions.

Dispersion models are predictive tools which utilize statistical representations of plume travel and dilution to predict contaminant ground level concentrations. Dispersion models predict concentrations that represent an ensemble average of numerous repetitions for the same nominal event. Generally, models are quoted as having a factor of two accuracy when compared to measured concentration data. Comparison studies have indicated that models can predict the magnitude of highest concentration occurring sometime and somewhere within an area to within ±10 to ±40% (i.e., within a factor of 2) of measurement data (U.S. EPA 2005a).

Air quality dispersion models such as CALPUFF employ assumptions to simplify the random behaviour of the atmosphere into short periods of average behavior. These assumptions limit the capability of the model to replicate every individual meteorological event. To compensate for these simplifications, five years of meteorological data are applied to evaluate a wide range of possible conditions. Additionally, regulatory models, such as CALPUFF, are designed to have a bias toward overestimation of contaminant concentrations (i.e., to be conservative under most conditions).

Emissions from the Project will employ a conservative worst-case hourly emissions approach (i.e., based on MOE guidelines), which is expected to over-estimate longer-term averaging periods. Because of the nature of this approach, there is a high degree of confidence that total emissions will be over-estimated. Therefore, even though the MOE approved air modelling exercise to be undertaken for the Durham/York EA Study will have some level of uncertainty associated with the results, the expectation would be that the modeling should over-estimate ground level concentrations under most circumstances.

2.1.2 **Risk Assessment Studies and Baseline Chemical Studies**

Of the utmost importance to local stakeholders and the public is the protection of public and environmental health, from exposure to chemicals released to the environment from the Project.

A site-specific HHERA is the most appropriate mechanism to assess the potential environmental effects on the health of people and wildlife. Any chemical, from the least toxic to the most toxic to which humans and ecological receptors can be exposed, has the potential to cause environmental effects: it is the concentration, duration of exposure and route by which receptors come into contact with a particular chemical that determines if it may cause harm to their health.

Findings of the other technical studies will be incorporated in the HHERA to ensure that the assessment is an accurate reflection of the data gathering completed for the EA Study. The HHERA relies on predictions of the anticipated concentrations of chemicals released by the Project, as determined from the outputs of the dispersion and deposition modeling conducted to characterize the potential environmental effects to the atmospheric environment. Data gathered to characterize the existing concentrations of chemicals in the environment (terrestrial, aquatic and air baseline chemical studies) provide needed information for the HHERA.

The purpose of the HHERA is to quantify the potential risk of adverse environmental effects occurring, including cumulative environmental effects, to the health of human and ecological receptors from both short-term and long-term (over the life of the facility) exposure from facility emissions.

Risk assessment of facility emissions is conducted in an iterative fashion (Figure 2-1). If during the study a potential risk is identified for one or more of the chemicals modeled from the facility, then the Risk Assessment Study Team works with the Air Quality Study Team and the facility design engineers to ensure that the appropriate level of pollution control technology has been incorporated into the original facility design.

If changes are required to facility design, then a reassessment of the new chemical emissions concentrations are undertaken to understand if they are sufficient to ensure the protection of health and the environment.

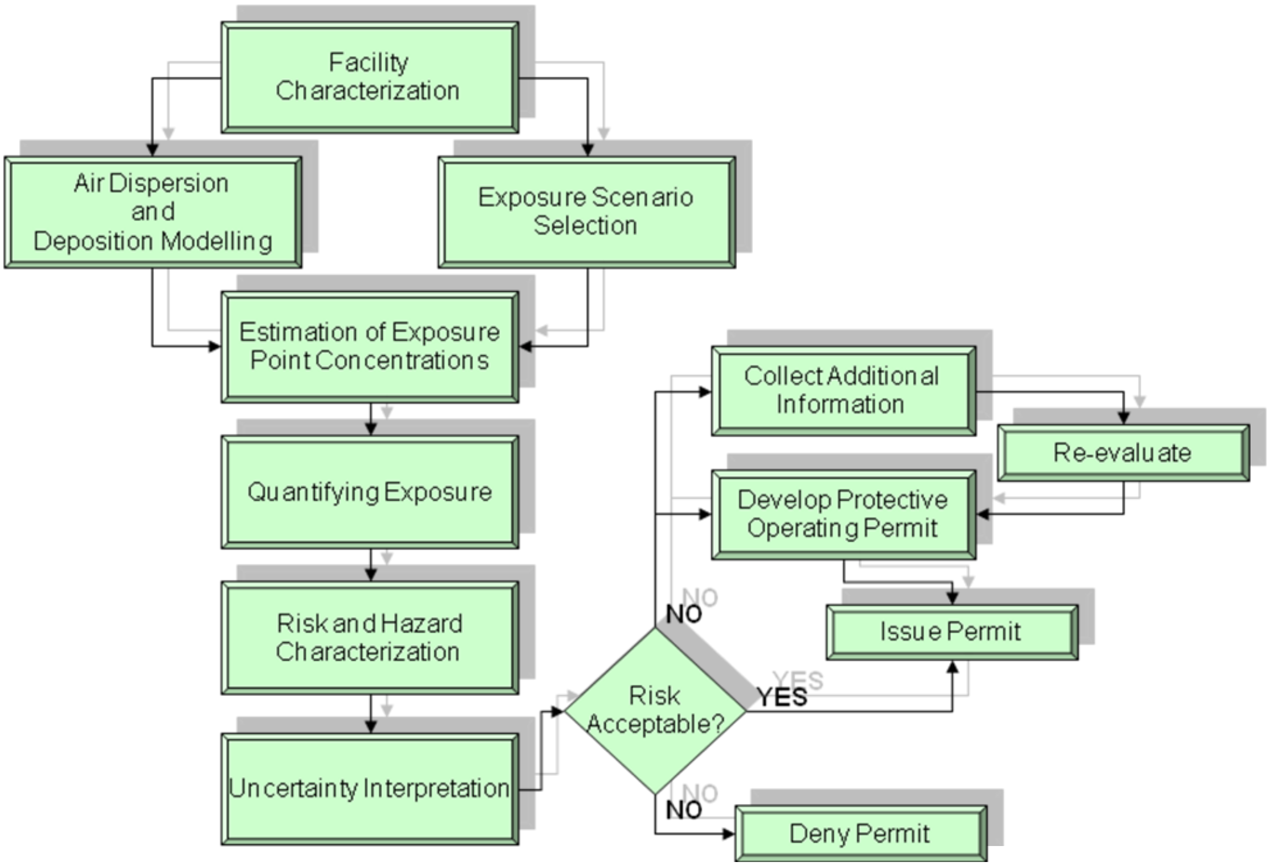

FIGURE 2-1 ITERATIVE APPROACH TO FACILITY EMISSIONS RISK ASSESSMENT

Uncertainties are inherent in every aspect of the risk assessment process. Generally, these uncertainties are addressed by incorporating very conservative assumptions in the analysis. As a result, risk assessments invariably overstate the actual risk. Although many factors are considered in the preparation of the risk analysis, results are generally only sensitive to very few of these factors. In any risk assessment an accompanying uncertainty analysis should be included to demonstrate that assumptions used were conservative, or that the analysis results are not sensitive to the key assumptions.

The site-specific HHERA to be completed for the Durham/York Residual Waste EA Study will provide a high degree of confidence in the conservative nature of its undertaking by:

- The nature and the scope of the risk assessment will be defined with a high level of certainty based on data used and physical observations; and
- An appropriate level of conservatism in all assumptions will ensure that risks are overstated and an appreciation of the bounds and limitations of the HHERA conclusions will be provided.

One such example of inherent conservatism in human health risk assessment is the toxicity reference values (TRVs) that are used as benchmarks for assessing exposure to chemicals emitted from the EFW facility. For those chemicals that cause effects other than cancer (e.g. liver disease), toxicological studies are conducted to determine a concentration at which there is no-observed-adverse-effect (NOAEL) from exposure. Thus if one was exposed to this concentration of a particular chemical one would not expect a health effect to manifest. However, in order to address uncertainties in these toxicological studies regulatory agencies, such as Health Canada, the World Health Organization and the US EPA, incorporate a number of "safety factors" known as Uncertainty Factors (UFs) that are used to lower the TRV well below the level at which adverse health effects have been reported in test species. These factors are applied in increments of 10, with overall additional levels of conservatisms ranging between 100 and 10,000.

Therefore, any environmental surveillance program to be adopted for oversight of the Durham/York EFW facility should be grounded on the understanding that the air quality and risk assessments are inherently conservative in nature and overstate actual risks that may manifest in humans or the environment.

2.2 Key Study Terminology

In order to meet the mandate of the current study, programs such as environmental surveillance, and its components – biomonitoring, studies and surveys were reviewed. The following sections serve to introduce, define and provide background information on each of the terms that will be used in this study.

2.2.1 Environmental Surveillance and Monitoring

Surveillance is a continuous and systematic process of collection, analysis, interpretation, and dissemination of descriptive information for monitoring health problems (Rothman and Greenland, 1998). *Monitoring* is the intermittent performance and analysis of routine measurements, aimed at detecting changes in the environment or health status of the population (Last, 2000). Surveillance is distinguished from monitoring by the fact that it is continuous and ongoing, whereas monitoring is intermittent or episodic.

The following sections further define the concepts of environmental surveillance, biological monitoring, surveys, and studies. The hierarchy of environmental surveillance is provided in Figure 2-2.

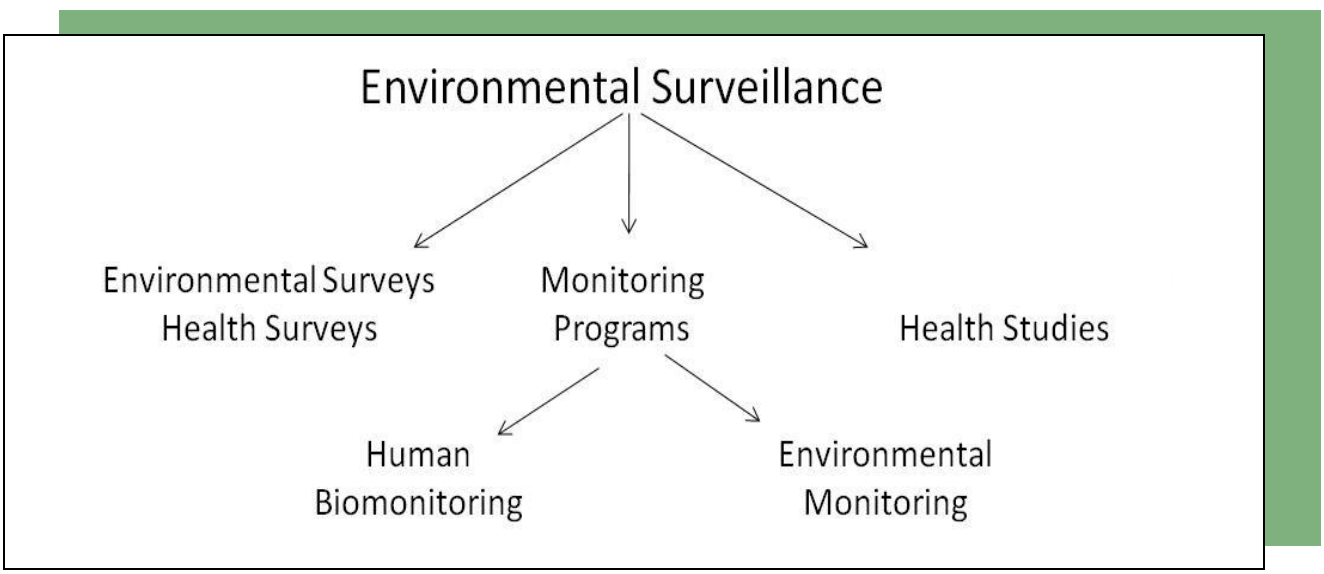

FIGURE 2-2 ENVIRONMENTAL SURVEILLANCE HIERARCHY

2.2.2 Environmental Surveillance

Environmental surveillance is a broad topic under which a wide range of information can be collected on exposures based on emissions data, dispersion modeling, and the monitoring of air, water, soil, vegetation, fauna and humans. It can include various possible programs, such as biological (including environmental and human) monitoring, health studies and health/environmental surveys.

Environmental surveillance can be a useful tool in the overall life-cycle assessment of chemical-emitting facilities. As with any combustion process, chemicals emitted can be deposited over variable distances, although the highest ground-level concentrations tend to be found in close proximity to the facility. Developments in pollution control technology have greatly reduced the amount of chemical emissions from EFW facilities; however some level of surveillance could be required to ensure that predictions made in the air modeling and risk assessment are valid upon commissioning of a facility.

2.2.3 Environmental Surveys

An environmental survey is the observational study of the ecosystem and its physical components through the use of scientific design and survey methodologies to evaluate potential stressors on the environment (UN FAO, 1990). These surveys are also often referred as biophysical surveys and do not involve sampling or sacrificing flora or fauna, rather they are observational.

These studies are particularly useful in understanding holistic interactions of ecosystems in areas that may be subject to environmental stressors. An environmental survey was conducted as part of the terrestrial and aquatic chemical baseline study currently underway at the site.

2.2.4 Health Surveys

Health surveys collect information from participants about their health, habits and life circumstances through a variety of means, including through interviews (conducted in person or over the phone), or by self-administered questionnaires (WHO, 2008). They are often used to provide information on the health status of communities and estimates of health determinants.

Health surveys are integral components of national programs such as NHANES in the United States, the CHMS (Health Canada, 2007a), and the Maternal-Infant Research on Environmental Chemicals (MIREC) (Health Canada, 2007c) projects underway in Canada. Programs such as NHANES have contributed to significant scientific findings such as the link between high levels of cholesterol and heart disease (NHANES, 2007).

Health surveys, or questionnaires, are often used in conjunction with human biomonitoring programs to obtain information on potential confounding factors that might affect the results.

2.2.5 Health Studies

The objective of a health study is to investigate a health concern using appropriate methods of discovery as governed by the nature of the concern. Health studies differ from surveillance and monitoring programs in that they seek to identify the relationship between individual characteristics and the occurrence of disease or outcome. The identification of the health concern or issue, however, may stem from the results of surveillance or monitoring programs. In the case of environmental health studies they are designed in a systematic way to scientifically explore and evaluate exposure-outcome relationships (ATSDR, 1996).

Health studies are typically retrospective in nature and there are major differences in the types of studies that can be done. The Agency for Toxic Substances and Disease Registry (ATSDR) of the Centers for Disease Control (CDC) in the United States separate environmental health studies into two types. Type 1 studies are often conducted to explore health concerns or potential exposures and determine the need for a more definitive study. Type 2 studies require a higher level of scientific rigor and often involve the use of the case-control or the cohort approach (ATSDR, 1996).

2.2.6 **Environmental Monitoring**

Environmental monitoring is rather similar in nature to human biomonitoring (Section 2.2.7), with the major difference between the two programs residing in the nature of the matrix under study – rather than collecting biological samples from humans, test media include ecosystem components such as soil, water, air, vegetation and fauna (*e.g.,* fish, small mammals, and birds). Stack testing of facilities emissions (whether periodic or continuous) is also considered a component of environmental monitoring.

An example of environmental monitoring already in place for the Durham/York Residual Waste Study is the ambient air monitoring that has been occurring at the Courtice Road site for the past year (Jacques Whitford, 2008) and the terrestrial and aquatic chemical baseline study currently underway at the site.

Environmental monitoring programs are often used as a means to determine, whether or not, there has been an increase in chemical concentrations in sample media as a result of an individual facility's emissions. Depending on the nature of the facility, a sufficient level of monitoring to evaluate potential chemical impact on the environment may be stack testing, or a combination of stack testing and ground level air monitoring, of chemicals. In some cases these programs may be augmented by the periodic collection of soil, sediment, water, vegetation or fauna samples to evaluate whether there has been an increase in chemical concentrations in the sample media over the operational life of a facility.

Environmental monitoring is often used as a surrogate to ensure protection of human health. If levels of contaminants do not increase in the environment, then in general one would not predict an increased risk to human health. However, design and implementation of these programs may be vastly different by industry, and should be developed based on the type of facility emissions and predicted magnitude in potential changes in environmental chemical concentrations that would result from its operation.

For example, under the Metal Mining Effluent Regulations (MMER), metal mines operating in Canada must monitor their discharge water and comply with effluent discharge limits for a specified list of chemicals. In addition, the regulation also requires that an environmental effects monitoring program must be carried out at each mine to determine whether the mine effluent affects fish, fish habitat or the usability of fisheries resources. This level of monitoring is used to ensure not only the protection of the environment, but also for the protection of people who may be using the receiving water body and eating the fish in lakes that receive mine effluent discharge.

2.2.7 **Human Biomonitoring (Biological Measures of Exposure)**

Human biological monitoring, more commonly known as human biomonitoring (HBM), is the measurement of specific substances in the human body, usually through the analysis of blood, urine, breast milk and tissue samples. Health Canada (2007a) defines biomonitoring as:

> *"the measurement of a chemical, the products it makes after it has broken down, or the products that might result from interactions in the body. These measurements are usually taken in blood and urine and sometimes in other tissues such as hair, saliva and breast milk"*.

This clarification is important because the "biological marker" may not be the chemical in the environment itself, but some metabolite resulting from the body's interaction with the chemical.

Angerer et al. (2007) identified four major requirements for a successful HBM program:

a) suitable biological matrices,
b) suitable parameters, able to reflect exposure or effects of interest (i.e. biomarkers),
c) suitable and reliable analytical methods controlled by quality assurance, and,
d) reference and limit values for the interpretation of results.

Blood and urine are the most commonly used biological matrices, while breast milk, semen, hair, saliva, and various other human media have also been analyzed (Angerer et al., 2007). These media are most commonly used because they are easily accessible and are the least intrusive samples that can be taken from the human body. Different analytical protocols exist for each medium and some media are more suitable for the detection of specific chemical parameters than others. The specific goals of the study would determine the media required for analysis.

Biological markers (i.e. biomarkers) represent the parameter of interest in the biological matrix under study. Many metals and organic pollutants can represent feasible biomarkers based on the expanded analytical capacity to detect very low levels of a compound in various media. Biomarkers are not required to be chemical in nature; protein and DNA adducts are examples of commonly used biochemical biomarkers (Angerer et al., 2007). As with many industrial activities, to date, no incinerator-specific biomarker has been identified that can be used to exclusively distinguish chemical exposure from incinerators from all other environmental contaminant sources (NRC, 2000).

Major developments in analytical chemistry over the last half-century have allowed for the low-level detection of many biomarkers in biological matrices. Quality control and assurance schemes have been developed by numerous countries to advocate the following of standard operating procedures by analytical facilities (Angerer et al., 2007). In Canada, for example, the Centre de Toxicologie du Quebec have developed quality assessment schemes and proficiency testing materials for a number of metals in various biological matrices (CTQ, 2006).

The final key component of a successful HBM program is the availability of chemical reference values in biological matrices for the interpretation of results. This most often takes the form of baseline monitoring programs which attempt to establish common or reference levels of biomarkers in media for various populations. An example of such a program would be a national HBM program such as the National Health and Nutritional Examination Survey (NHANES) in the United States or the Canadian Health Measures Survey (CHMS).

Only when all four criteria are met can a successful HBM program be undertaken. These four criteria will be considered during the review of HBM studies found in this study in order to establish confidence in their study protocols and results.

HBM programs are often undertaken as a result of a known environmental issue, in an attempt to determine whether or not people have been exposed to chemicals and if possible to evaluate the significance of the exposure. An example of such a program is the use of blood lead testing in children that may be exposed to elevated environmental concentrations of lead in their homes. Children living in older homes may be exposed to elevated lead in their drinking water or from lead-based paints in the home. A simple blood lead test can be used to compare measured blood lead levels to action levels published by Health Canada. If the child is found to have elevated blood lead levels, then action is taken to remove potential exposure sources, such as lead pipes supplying drinking water or covering lead-based paints.

2.3 Terminology Used in Distinguishing Between Types of EFW and Incineration Facilities Reviewed

This study reviews best practices of environmental surveillance related to EFW facilities. However, the scientific literature on environmental surveillance options does not always distinguish between EFW and non-EFW facilities; therefore the search was appropriately widened to include all manner of incineration facilities. The Study Team has distinguished between the types of incineration facilities that were studied by the researchers (e.g., municipal solid waste, hazardous waste or medical waste) throughout the report. The importance of this distinction is that the feedstock (material going into the process) may contain different levels of chemicals in the material that was being incinerated.

In addition, the Study Team felt that it was important to distinguish between facilities that were built and operated with modern pollution control technology, from older facilities that may have emitted higher concentrations of chemicals than would be allowed by regulation in Ontario today.

In 2000, the European Directive 2000/76/EC was agreed to by member countries and published on December 28, 2000. For many chemicals, allowable stack emission concentrations were either lowered, or in some cases established. The province of Ontario followed suit in 2002 with publication of its first iteration of the A-7 Guideline (updated in 2004), which also lowered emissions standards from its previous Guideline A-1.

Prior to these emission standards taking effect, changes in efficacy of pollution control technology for incineration facilities was developed and implemented around the EU. Therefore, the reviewers considered facilities that were built and became operational in the late 1990s to be “modern” facilities that employ the latest in pollution control technology for reducing chemical emissions to the environment.

Those facilities that were operating prior to the late 1990s were considered “older” facilities in this review as they generally emitted higher concentrations of chemicals (e.g. dioxins and furan [PCCD/F]), into the environment. It was also noted that several studies published after the late 1990s included an assessment of older facilities. The environmental surveillance programs in place for these facilities were deemed relevant to this study, but caution was applied when interpreting their findings and their applicability to the type of pollution control technology and emission standards that would be adopted for the Durham/York proposed EFW facility.

3.0 SYSTEMATIC SCIENTIFIC LITERATURE REVIEW

3.1 Systematic Literature Review Objectives, Methodology and Results

The objective of the systematic scientific literature review was to identify relevant English-language literature on the current practices employed in environmental surveillance programs initiated by EFW or incineration facilities around the world, with a publication date of January 1, 1990 or later. Pollution control technology has improved substantially over the preceding decade and this cut-off date should ensure that studies identified during this period reflect current industrial technology, while also allowing for inclusion of long-term (multi-year) studies that were published in the scientific literature.

Guidance for the development of the article search and evaluation process has been outlined by the Cochrane Handbook for Systematic Reviews of Interventions (Cochrane Collaboration, 2008). The Cochrane Handbook is the standard for conducting information reviews in the health care and pharmaceutical industries. Cochrane reviews adhere to the principle that "science is cumulative" and by considering the available evidence, decisions can be made that reflect the best science available. Although the Cochrane review methodology may have been designed to answer research questions in the health care industry, the applicability of the methodology is widespread because the key characteristics of the review process are broad. The Cochrane Handbook cites the five key characteristics of a systematic review as:

- A clearly stated set of objectives with pre-defined eligibility criteria for studies;
- An explicit, reproducible methodology;
- A systematic search that attempts to identify all studies that would meet the eligibility criteria;
- An assessment of the validity of the findings of the included studies, for example, through the assessment of the risk of bias; and,
- A systematic presentation, and synthesis, of the characteristics and findings of the included studies.

This scientific process and the ensuing systematic review strived to adhere to these five key characteristics. A professional Health Sciences Information Specialist/Librarian, trained and practicing in the field of health sciences systematic review was engaged for this project.

3.1.1 Search Procedure

Figure 3-1 provides an overview of the systematic literature review process. The search strategy, developed by a Health Sciences Information Specialist/Librarian in consultation with the Review Team, was undertaken for the purposes of locating relevant studies for this report.

The following bibliographic databases were searched: Ovid's Medline In-Process & Other Non-Indexed Citations, Medline and EMBASE; The United States National Library of Medicine's PubMed (limited to non-Medline items) and TOXLINE; Wiley's Cochrane Library; Thomson's BIOSIS Previews; and Cambridge Scientific's Environmental Science and Pollution Management. A high degree of overlap was encountered when searching all seven databases; however, this exhaustive search ensured a greater coverage of the potential scientific literature on the subject.

Conduct and Combine Database Searches

OVID MEDLINE (In Process), OVID MEDLINE, PUBMED, TOXLINE, ESPM, Cochrane Library, BIOSIS Previews

Exclude articles published pre-1990

↓

Review Abstracts (Tier 1)

Exclude articles deemed not relevant.

Criteria for inclusion:
- *English Language*
- *Study Focus: Environmental Surveillance at Incineration Facilities*

↓

Review Full-Text Articles (Tier 2)

Exclude articles deemed not relevant.

Criteria for inclusion:
- *Article available in full-text*
- *Clearly defined study population*
- *Explicitly studied EFW by-products exposure*
- *Measurable outcome of interest*

↓

Final Article Count

Apply Information Collection Form and Quality Assessment Framework to articles.

FIGURE 3-1 OVERVIEW OF THE SCIENTIFIC LITERATURE SYSTEMATIC REVIEW PROCESS

Appendix A outlines the search strategy and logic used. The searches covered the period from 1990-present. Language restrictions were not employed during database searches; however, only English language articles were ultimately included in the review. Due to the fact that a large proportion of the indexed scientific literature is published in English, and because of the delays associated with translation of international articles, it was felt that this language restriction would not significantly decrease the effectiveness of the review. As with any search strategy, every attempt was made to balance elements of comprehensiveness and relevance. For instance, increasing the comprehensiveness of a search is likely to reduce the general relevance of the search results (Cochrane Collaboration, 2008).

After the bibliographic records were compiled, duplicate items were eliminated and the titles/abstracts of all articles were reviewed to assess their relevance to the review (Tier 1 Screening). This process was completed using Reference Manager (v.11, Thompson ResearchSoft, Philadelphia, PA, USA). If abstracts were not available, relevance was judged from the title of the article. Citations were excluded if incineration (or any appropriate synonym) was not mentioned or if the outcome of interest was not relevant to the systematic review.

Relevant criteria included:

- The study population is clearly defined and relevant: human or environmental media;
- Exposure to EFW or incineration by-products was explicitly studied; and
- The outcome of interest was a human health, biological or environmental measure.

Titles and abstracts (when available) of all search results were screened by dual (2) reviewers using predefined criteria in order to identify English language publications that discussed environmental surveillance programs for incineration facilities. When it could not be determined from the information available whether an article met the inclusion criteria or not, the article was advanced to the full-text review. The initial inter-rater agreement (Cohen's Kappa co-efficient) between the reviewers was 0.43. This score identifies that the reviewers were in "moderate agreement" with the inclusion and exclusion of articles. This Kappa co-efficient score is a lower value than expected. It should be noted that much of this disagreement was experienced in the beginning of the Tier 1 screening, thus lowering the final Kappa co-efficient score. A systematic review of this nature has not been undertaken in the past, and the ambiguous character of some citations (i.e. limited information in the title and abstract) made it challenging for the reviewers to be in mutual agreement as to whether to include or exclude some citations. Discrepancies between the reviewers were discussed until a consensus was reached. Prior to proceeding with the systematic review a subsequent inter-rater agreement test was performed and resulted in a score of 0.90, which identifies that reviewers were in "almost perfect agreement".

The articles that passed initial title/abstract review were obtained and reviewed in full-text form (Tier 2 Screening). If full-text articles could not be obtained through reasonable means, then they were excluded from further review. Review of full-text articles was conducted to identify publications with a study focus on environmental surveillance, the type of surveillance program, and depth of analysis. Articles were excluded if the study focus was on stack emission monitoring programs, epidemiologic or health effect studies, source apportionment studies or risk assessments. These topics are outside of the scope of this review. In addition, when reviewing full-text articles the reference lists were also reviewed (termed "back-referencing"). This was done to identify potentially relevant documents that were not recovered in the initial literature search.

3.1.2 Data Abstraction and Analysis

For studies that focused on environmental surveillance programs, data was abstracted using two standard forms (see Appendix C) to record details of the study design and methods, study/control group characteristics, statistical analysis, and outcomes of interest. Two forms were used because environmental and human biomonitoring studies had different recordable characteristics. The environmental monitoring studies were then further stratified based on the media studied (ambient air, soil, vegetation, fauna). In some cases the studies assessed more than one type of media. In these instances a record of the study was put into each relevant category.

Once data was abstracted the study underwent a quality assessment to identify the confidence that could be placed in the results and practices employed in the article. A high degree of confidence in the results was essential to establish reliance on the conclusions of the review. The quality assessment framework used was founded on a combination of two systems:

1) that used by Dr. Lesbia Smith's epidemiological review of the human health effects of energy-from-waste facilities, commissioned by the Medical Officer of Health for the Region of Durham (2007); and,

2) The use of the GRADE approach for grading quality of evidence as recommended by the Cochrane Handbook for Systematic Reviews of Interventions (2008).

Each article under review was assigned a quality level ranging from high to very low in each of four separate categories: study design, study/control group selection, sample collection and critical results analysis. In order for the studies to be included in the systematic review the study had to achieve a score of "Moderate" in all categories. If the article had any category with a value of "Low" or "Very Low", the study was subsequently excluded from the systematic review. Table 3-1 summarizes the quality assessment framework. Where necessary, this framework was adapted to better conform to the nature of an article.

TABLE 3-1 SCIENTIFIC LITERATURE REVIEW - QUALITY ASSESSMENT FRAMEWORK

Category	Quality Level	Required Criteria
Study Design	High	- Retrospective and longitudinal study - Presence of study and multiple control groups - Adequate sample sizes to detect statistical differences - Baseline sampling results exists or conducted as part of study
	Moderate	- Cross-sectional study - Presence of study and single control group - Adequate sample sizes to detect statistical differences?
	Low	- Cross-sectional study - Presence of study group but no control group - Adequate sample sizes to detect statistical differences?
	Very Low	- Unspecific study type - Presence of study group but no control group - Sample sizes not adequate for proper interpretation of statistics
Study/Control Group Selection	High	- Participant/location selection method is fully detailed - Study group within typical deposition ranges of EFW; control group outside of EFW deposition range - Significant length of exposure to EFW - Groups controlled for *all* confounding factors: age, sex, socioeconomic status, occupational and other sources of exposure
	Moderate	- Brief to full detail on participant/location selection method - Study group within typical deposition ranges of EFW; control group outside of EFW deposition range - Significant length of exposure to EFW - Groups controlled for *most* confounding factors: age, sex, socioeconomic status, occupational and other sources of exposure
	Low	- Little detail on participant/location selection method - Study group within typical deposition ranges of EFW - Significant length of exposure to EFW - Groups controlled for *one or two* confounding factors: age, sex, socioeconomic status, occupational and other sources of exposure
	Very Low	- No detail on participant/location selection method - Study group not within typical deposition ranges of EFW - Insignificant length of exposure to EFW
Sample Collection	High	*Human* - Lifestyle and History Questionnaire completed by participants - Media (i.e. blood, urine, etc.) sampled by researchers directly, or by proxy (i.e. doctor, etc.) under researcher supervision - Analytical procedures outlined *Environmental* - Media (i.e. soil, water, etc.) sampled by researchers directly. - Collection methods, sample storage and sample preparation outlined - Analytical procedures outlined
	Moderate	*Human* - Lifestyle and History Questionnaire completed by participants - Media (i.e. blood, urine, etc.) sampled by researchers directly, or by licensed proxy - Analytical procedures outlined *Environmental* - Media (i.e. soil, water, etc.) sampled by researchers directly or by proxy. - Collection methods, sample storage and sample preparation outlined - Analytical procedures outlined
	Low	*Human* - Media (i.e. blood, urine, etc.) sampled by researchers directly, or by licensed proxy *Environmental* - Media (i.e. soil, water, etc.) sampled by researchers directly or by proxy.
	Very Low	*Human* - Data obtained from previously recorded patient records or effects self-reported by participants *Environmental* - Data obtained from previously conducted studies or from third-parties.
Critical Results Analysis	High	- Statistical analysis performed and procedure outlined - Issues of causality addressed - Conclusions are appropriate based on obtained results - Alternative hypotheses are considered
	Moderate	- Statistical analysis performed and procedure outlined - Issues of causality broached but not fully addressed - Conclusions are appropriate based on obtained results
	Low	- Basic quantitative analysis performed; no statistical analysis - Conclusions are appropriate based on obtained results
	Very Low	- Qualitative analysis only

3.1.3 Overall Search and Quality Assessment Results

The literature search was completed in October 2008 and identified a total of 4,491 citations (Figure 3-2). After duplicates were removed, and screening was completed, 189 articles were retained for data abstraction and quality assessment. No additional relevant studies were found by back-referencing, which can be attributed to the exhaustive nature of the database search.

Of the 189 articles, 66 were categorized as human biomonitoring studies, and 119 as environmental monitoring studies. An additional 5 were categorized as "Other" because the study focus was not necessarily the description of a specific monitoring program, but the content was nevertheless relevant to the review. When the quality assessment framework was applied to the human biomonitoring studies, 30 articles were excluded from the review (15 general population, and 15 incinerator worker studies), leaving 36 articles for inclusion in the study (Table 3-2). When the environmental monitoring studies underwent quality assessment, 60 were excluded, leaving 59 for inclusion in the study (Table 3-2).

TABLE 3-2 SUMMARY OF QUALITY ASSESSMENT RESULTS

Study Type	Total Number of Articles Abstracted	Number of Articles Excluded	Number of Articles Included
Environmental Monitoring	119	60	59
Human Biomonitoring	65	29	36

Table 3-3 provides a summary of the distribution of "Low" and "Very Low" scores given to articles that were excluded for interpretation in this study. In both human biomonitoring and environmental monitoring studies, the most common reason for excluding the studies was an invalid study design for the purpose of this environmental surveillance review. It was observed that some studies lacked control groups or baseline measurements which severely limited the reviewers' confidence in the outcomes. Other common reasons for excluding the studies were the absence of appropriate statistical or quantitative analysis in some studies, or, specifically with regards to human biomonitoring, the absence of a questionnaire to assess the personal and lifestyle factors of the participants. The removal of these articles for use in this study does not suggest they were not fit for scientific publication, rather that the specific aspects sought by the Study Team for consistency in our review were not apparent.

TABLE 3-3 QUALITY ASSESSMENT RESULTS

Study Type	Number of Articles Excluded	Number of Excluded Articles Receiving a Score of Low or Very Low[a]			
		Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis
Environmental Monitoring	60	55	50	5	28
Human Biomonitoring	29	16	10	15	11

Note: [a] Articles may have received a score of low or very low in more than one category

Regardless, a summary of the data abstracted for all scientific literature articles (both included and excluded) can be found in Appendix C. In addition, a number of occupational monitoring studies were retrieved during this study. Although the results are not directly pertinent to the development of an environmental surveillance program, the abstracted results are provided in Appendix J.

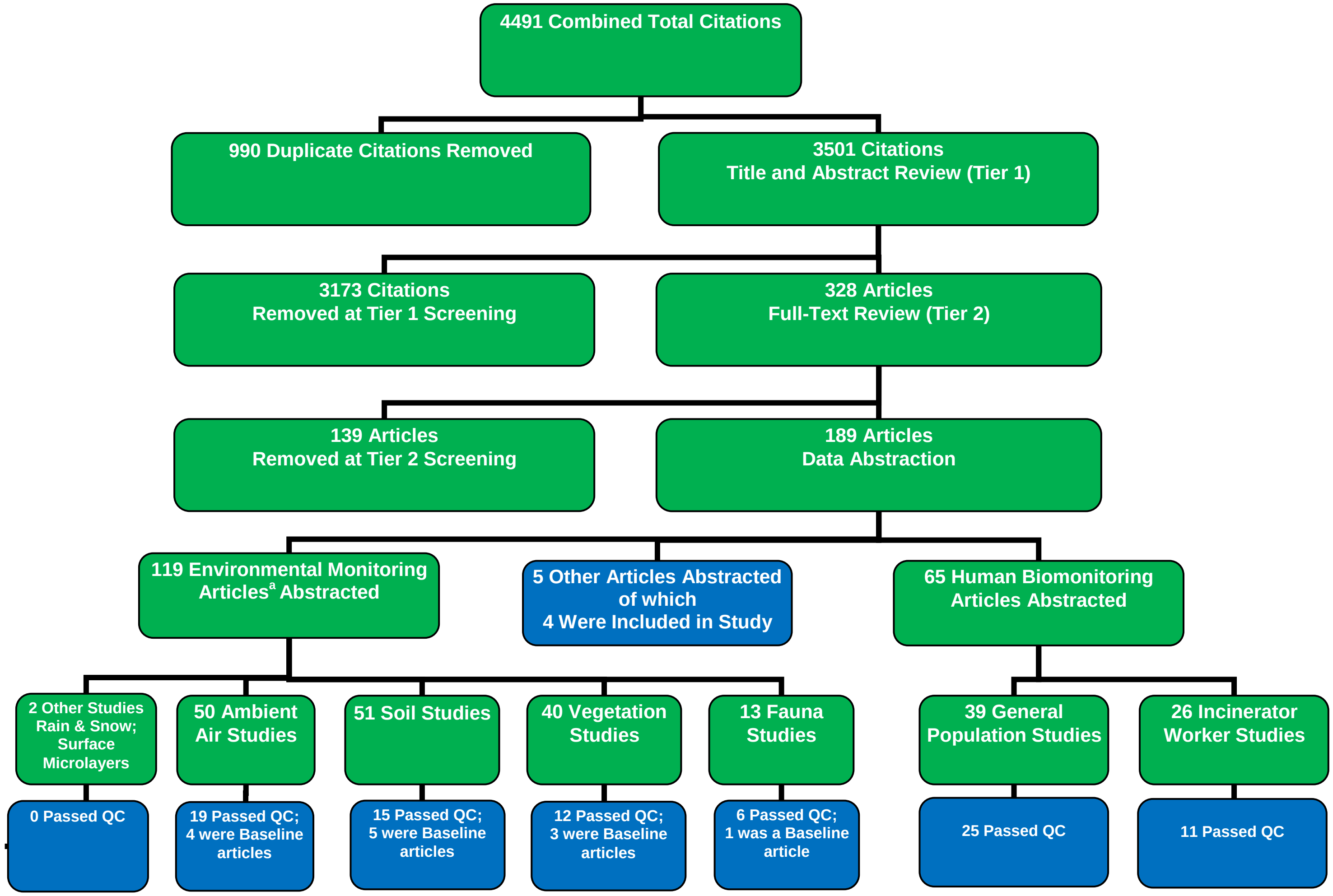

FIGURE 3-2 SUMMARY OF SCIENTIFIC LITERATURE REVIEW RESULTS (BOXES IN BLUE ARE THOSE STUDIES THAT PASSED QUALITY ASSESSMENT AND WERE INCLUDED IN THE REVIEW)

Note: [a] Environmental monitoring articles often involved more than one type of media and as a result, studies are included in multiple categories if appropriate.

3.2 Summary and Findings of the Included Scientific Literature

3.2.1 Baseline Studies Conducted Prior to Operation of an Incineration Facility

Eleven of the scientific articles retrieved, abstracted and included in this study were environmental baseline programs, conducted prior to an incineration facility becoming operational (Bobet et al., 1990; Stenhouse & Badsha, 1990; Cobb et al., 1993; Hippelein et al., 1996b; Hippelein et al., 1996a; Schuhmacher et al., 1997; Schuhmacher et al., 1998; Mateu et al., 1999; Llobet et al., 2000; Coutinho et al., 2001; Schuhmacher et al., 2002).

These environmental baseline programs typically involved the sampling of a number of chemicals in various environmental medium. In two instances, the environmental baseline programs were so comprehensive they were split into several publications - four publications for a hazardous waste incinerator in Catalonia, Spain (Schuhmacher et al., 1997; Schuhmacher et al., 1998; Llobet et al., 2000; Schuhmacher et al., 2002) and two publications for a resource recovery facility in Germany (Hippelein et al., 1996b; Hippelein et al., 1996a).

In general the sampling programs had similar objectives (i.e., establishing environmental baseline chemical conditions) and sampling methodologies. The sample locations were selected through review of atmospheric dispersion modelling results, which provide the predicted zone of influence of a facility's emissions. Baseline sample medium included ambient air, soil, vegetation, and bovine milk.

The number and frequency of sampling varied between studies. Continuous ambient air sampling stations were initiated at least 1 year before incinerator start-up. This was to identify any seasonal or temporal variation in ambient air chemical concentrations. Soil, vegetation and bovine milk samples were collected intermittently over 1 to 2 years prior to the incinerator start-up.

The chemicals measured in the baseline sampling programs were those which could be influenced by the presence of incinerator emissions. PCDD/Fs, metals (As, Be, Cd, Cr, Hg, Mn, Ni, Pb, Sn, Tl, V), and PCBs were the focus of the baseline sampling programs.

The authors of each study emphasized the importance of collection of an environmental baseline, so that samples collected and analyzed in the future could be benchmarked against pre-operational conditions.

Relevance to Current Study
These studies illustrate the importance of conducting chemical baseline investigations prior to commissioning of an EFW facility. It forms the benchmark against which any samples collected during the facility's operation would be evaluated.

3.2.2 Environmental Monitoring Studies

3.2.2.1 Ambient Air Monitoring Studies

The study design, methodology and sampling techniques for monitoring ambient air quality surrounding incineration facilities was consistent across the scientific literature, although the chemicals assessed varied from study to study.

In general, high volume air samplers were sited downwind of a facility and within its modelled chemical depositional range. In many studies a control location was set up in an area predicted to be outside of the zone of influence of the incinerator. This allowed the researchers to compare the ground level concentrations of chemicals within the zone of influence of the facility to background conditions. Dioxins and furans (PCDD/Fs), trace metals and volatile organic compounds (VOCs) were the most commonly measured chemicals.

3.2.2.2 Ambient Air Quality Studies on Modern Municipal Waste Incinerators

Ambient Air Monitoring Surrounding a Municipal Waste Incinerator in Spain. (Mari et al. 2008a, 2008c)
Source of Funding: Metropolitan Entity of the Environment, Barcelona, Catalonia, Spain.

Mari et al (2008a, 2008c) assessed chemical concentrations in the ambient air surrounding a municipal waste incinerator in San Adria Del Besos, Barcelona, Spain. The objective of the first study was to evaluate the concentrations of PCDD/F, PCBs, and PAHs in the ambient air at varying distances from the municipal waste incinerator (MWI), as well as to evaluate the efficacy of active and passive air samplers (Mari et al., 2008c).

Three sampling sites were established within the vicinity of a MWI and a combined cycle power plant. A semi-rural area close to a large park with no direct pollutant sources was used as a control site. PCDD/Fs, PCBs and PAHs were sampled over four months (March to June, 2005) with high volume air samplers and passive air samplers. Chemical levels were quantified using a high-resolution gas chromatograph/high-resolution mass spectrometry (HRGC/HRMS). The researchers concluded that the concentrations of most chemicals were higher in the industrial sampling sites when compared to the rural sampling site. However, they were not able to attribute the levels of chemicals in the air to the MWI.

Mari et al. (2008a) further assessed the impact of the municipal waste incinerator in San Adria del Besos, Barcelona, Spain. The objective of the study was to evaluate the concentrations of PCDD/F, PCBs, and metals (As, Be, Cd, Co, Cr, Cu, Mn, Ni, Pb, Sn, Tl, and V) in the ambient air at varying distances from the MWI, and to determine if there was any seasonal variation in ambient air concentrations.

> ***Relevance to Current Study***
> *Air samples should be located within 1 km of the facility, as the highest concentrations of chemicals would be within this zone of influence.*
> *These studies indicate that this facility is not a significant source of PCDD/F, PAH, PCB or metal contamination in the local airshed.*

Two sampling sites were situated 500 meters from the MWI and an additional site was set up at 1km from the incinerator. The control site from the previous study was retained for use. Sampling was conducted in the autumn of 2005 and the spring of 2006 with high-volume air samplers. Chemical concentrations of PCDD/Fs, PCBs were determined using HRGC/HRMS. Quantification of metals were extracted and analyzed with the appropriate tools such as atomic absorption spectrometry for Cr, Cr, Fe, Zn, graphite furnace for Al, Cd, Pb and cold vapor technique for Hg.

The study concluded that the MWI was not a large source of PCDD/Fs, PCBs and metal emissions and did not contribute significantly to the air pollution in its immediate surroundings. In addition, no temporal, seasonal or spatial variations were observed.

Atmospheric Impact Assessment and Monitoring of Dioxin Emissions of Municipal Solid Waste Incinerators in Portugal (Coutinho et al. 2007)

Source of Funding: LIPOR (Intermunicipal Waste Management of Greater Porto), Portugal

A study by Coutinho et al. (2007) assessed the atmospheric contribution of PCDD/F from three municipal waste incinerators in Porto, Lisbon and Madeira, in Portugal. The MWIs all had operation start dates between 1998 and 2000.

Nine ambient air monitoring stations were selected from a larger ambient air monitoring program conducted by the Institute for Environment and Development (IDAD). These nine stations were located in areas that were assumed to be within the deposition zone of the MWIs, though actual distances from the facilities were not provided. A control site was established in Poiso, which was upwind of any industrial pollution sources on the island of Madeira. A total 170 ambient air samples were collected from 1999 to 2004. PCDD/F concentrations were quantified using HRGC/HRMS.

Researchers found both spatial and temporal variation in the atmospheric PCDD/F concentrations. Porto and Lisbon had the highest concentrations of PCDD/Fs in ambient air, though no tangible explanation for these elevated concentrations were given. The researchers state that further analysis would be needed to link the PCDD/F levels to a source. Seasonal variation was also evident at these sites. In the winter PCDD/F concentrations were elevated. The researchers explain that this was a result of the seasonal variation in the elevation of the atmospheric boundary layer and an increase in the amount of wood burned in the winter. Concentrations in Madeira were characteristic of a background site. This was explained by the orographic characteristics of the location and absence of industrial activity in the area. The researchers concluded that extraneous variables may be responsible for the atmospheric PCDD/F concentrations for Porto and Lisbon, and that the MWIs did not have a significant impact on PCDD/F concentrations in on the atmospheric PCDD/F levels at any of the sampling locations.

Relevance to Current Study

The study indicates that a MWI facility with modern pollution control technology was not a significant source of PCDD/F in the local airshed.

3.2.2.3 Ambient Air Quality Studies on Older Municipal Waste Incinerators

Effect of a Municipal Waste Incinerator in Albany New York, United States on Metals and Anions in Ambient Air. (Koblantz et al., 1997)
Source of Funding: No Funding Discussed

Koblantz et al. (1997) studied ambient air emissions relating to an older MWI that began operating in 1981 in Albany, New York. The sampling program was requested by the public over concern about particulate emissions from the MWI and an adjoining oil-fueled plant. The objective of the study was to determine if the plant was emitting trace metals (Ba, Cu, Fe, Mn, V, Zn, Ca, Ni, Pb) and anions (SO_4, NO_3, Cl) into the surrounding atmosphere. If so, were the levels elevated enough to cause negative impacts on public health.

In, 1993, 4 ambient air monitors were set up in locations ranging from 400 meters to three kilometers from the incinerator stack. Ambient air samples were also collected at the same sites in 1994 when the plant was not in operation. Samples were collected with high-volume air samplers, equipped with quartz and glass fiber filters. Chemical analysis was performed by inductively coupled plasma emission spectrometry (Ba, Cu, Fe, Mn), atomic absorption spectrometry (Cr), inductively coupled mass spectrometry (As, Be, Cd, Ni Pb) and cold vapor atomic absorption spectrometry (Hg). Ion chromatography was used to quantify SO_4, NO_3 and Cl ions.

Relevance to Current Study
This study concluded that the MWI was not a significant source of metals in ambient air surrounding the facility. Factor analysis and principal component analysis can be used to determine if the incineration facility is a statistically significant source of pollution.

No difference in ambient air chemical concentrations were measured between the 1993 (operational) and 1994 (non-operational) sampling events. There was also no difference in chemical concentrations at sample locations upwind and downwind of the facility. Therefore, the authors concluded that the facility was not impacting local ambient air quality. Statistical factor analysis and wind-direction correlations revealed that chemical concentrations in air at Albany were components of mixed-air masses, with contributions from a variety of regionally distributed sources.

The Effect of Three Municipal Waste Incinerators on PCDD/F Concentrations in Ambient Air in Italy. Caserini et al., (2004)
Source of Funding: AEM Cremona, and the Municipality of Bolanzo

Caserini et al (2004) assessed PCDD/F concentrations at three Italian sites (Po Valley, Veneto Region, and Adige Valley) where municipal waste incinerators were operating. The municipal waste incinerators began operations in 1998 (S1), 1983 (S2), and 1994 (S3) respectively. The objective of the research was to determine what degree of influence each MWI has on PCDD/F levels in ambient air.

Relevance to Current Study
The research provided clear evidence that age and pollution control technology of an incinerator has an effect on the chemical concentrations found in the surrounding ambient air. It also emphasized the need for a control sample to compare results.

Ambient air samplers were set at distances ranging from 750 m to three kilometers from the facilities. S1 samples were collected between 1997 and 2000, S2 samples were collected in 2000 and 2001, and samples from S3 were collected in 2001. Three control sites (one for each location) were located outside of the facility's modelled depositional area. Air samples were collected in high and medium-volume air samplers, which were equipped with glass fiber filters and PUF plugs. The analysis of the PCDD/F concentrations was done with HRGC/HRMS.

The incinerator at S1 and S3 did not impact local ambient air concentrations of PCDD/F. This was attributed to the fact that S1 was representative of a modern MWI facility with advanced pollution abatement technology, while S3 also had good pollution control. Location S2 was shown, in combination with other PCDD/F sources in the area to have an influence on ambient air. Poor pollution abatement technology at the S2 MWI was cited as the reason for its contribution to elevated PCDD/F levels in ambient air. The researchers concluded that the age of a MWI and the pollution control technologies employed at a facility have a direct link to the PCDD/F concentrations found in ambient air surrounding a facility.

Summary of Nine Older MWI Facilities Where a Positive Correlation with Air Quality Impacts Were Observed.

The following is a summary of a number of research articles that studied ambient air quality surrounding older municipal waste incinerators (Table 3-4). A clear distance-decay effect of chemical concentration with distance from the older MWI was observed from the evaluation of the studies. The highest chemical concentrations were found at sampling sites in close proximity to the incinerator stack (<500m). Facilities with the oldest commissioning (start) dates also tended to most greatly impact ambient air quality surrounding the facilities. This observation is likely an indication that the facilities lacked modern pollution control technology to mitigate the chemicals being released from the facility.

Relevance to Current Study
The studies that found a positive correlation to stack emissions demonstrate the need for an ambient air monitoring program for older incinerators. Emphasis should be placed on locating sampling points with approximately 100 meters from the stack due to higher chemical depositions within this threshold and a strong distance decay effect.

TABLE 3-4 SUMMARY OF INDIVIDUAL AMBIENT AIR MONITORING STUDIES THAT IDENTIFIED A CORRELATION WITH AN INCINERATION FACILITY

Reference	Location	Type of Incinerator	Start Date	Study Design	Key Conclusions	Funding
Abad et al., 1997	Catalonia, Spain	Industrial and Municipal Waste	Not Reported	21 ambient air samples were collected at sampling sites either in the area or under the influence of the industrial incinerators or the municipal waste incinerators (no actual distances given) 14 control samples were collected in areas not under the influence of the MWI	PCDD/F concentrations in ambient air in sampling sites in close proximity to the facilities were assumed to be from the incinerators. Ambient air had the same profile as stack gas.	Not Reported
Agrell et al., 2004	Malmo, Sweden	Municipal Waste (SYSAV)	1971/ retrofitted in1995	Ambient air samples were collected from 2 sites within the depositional ranges of the MWI Control samples were collected at a rural reference site.	Polybrominated diphenyl ethers were significantly higher at sites that were closest to the MWI as compared to the reference sites.	Not Reported
Besombes et al., 2001	Large urban area, France	Municipal Waste	Sampling conducted in 1999. Operational	14 ambient air samples were collected at 2 sites. Site B was located less than 10 meters from the incinerator	PAH levels in the immediate area (10 meters) of the MWI could be attributed to the stack	ADEME, France

Reference	Location	Type of Incinerator	Start Date	Study Design	Key Conclusions	Funding
			start date Not Reported	Site C was located about 2300 meters from the incinerator A control sample was collected from an area 1km upwind of the incinerator	emissions	
Chang et al., 2003	Northern Taiwan	Municipal Waste	1995/ Retrofitted in March 1999 with activated carbon injection to reduce PCDD/F emissions	14 samples were taken within the depositional ranges of the MWI. 1.4 to 3.1 kms from the MWI 4 control samples were collected in a rural reference area not within the depositional ranges of the incinerator	PCDD/F concentrations in sampling sites downwind and in areas close to the incinerator had the highest PCDD/F concentrations.	National Science Council of the Republic of China
Lorber et al., 1998	Columbus, Ohio	Municipal Waste	1983	16 Ambient Air samples were collected in 1994 and 1995 and taken at 1.8 to 3.90 kms from the MWI 3 ambient air samples were collected in an area 45kms away from the MWI	PCDD/F concentrations were highest at the sampling site close to the MWI (1.8 km away). Stack and ambient air profiles were found to be similar indicating that the PCDD/F concentrations in ambient air are resultant from the MWI	Not Reported
Oh et al., 2006	Bucheon City, Korea	Municipal Waste	1995	Ambient Air was sampled at 3 sites within 1 km from the MWI A control sample was collected from Mt. Dobong, a national park located 30kms away from the MWI	MWI was the major emission source but confounding variables may attribute to some PCDD/F levels	Korea Science and Engineering Foundation
Roth & Riggs, 1998	Montgomery County, Ohio, USA	Municipal Waste	Prior to 1988	2 MWI's in this study 6 samples: 2.4km N of MWI(1) 6 samples: 1.6 km E-NE of MWI (1) 6 samples: 0.5 km SW of MWI (1) 6 samples: 1.4 km NE of MWI (2) (sample directly downwind) A control sample was collected 13 kms west (upwind) of the MWIs	Approximately 70% of PCDD/F concentrations attributable to the MWI were found <2kms from the MWI. 11% of attributable air emission were found at 2.4 kms from the MWI	Not Reported
Blanch & Bianchi, 1999	Southampton, England	Municipal Waste	Operational Start Date Not Reported MWI closed November 1996	Ambient Air stations were set up at 9 locations ranging from 75 meters to 300 meters from the MWI Baseline was determined after incinerator shutdown	Concentrations of volatile organic compounds in sampling sites close (approx 75 meters) to the MWI decreased after the MWI closed.	Not Reported
Bolt & De Jong, 1993	The Netherlands	Municipal Waste	Not Reported	Ambient air sampled were collected at various wind directions at a distance of about 10km NE from the incinerator A control site was located in a rural area of unspecified distance from the MWI	Congener profiles of PCDD/Fs were similar in fly ash and ambient air emissions. Highest values were found in sampling sites that were in close proximity and downwind of the MWI	Not Reported

3.2.2.4 Ambient Air Quality Studies on Non-Municipal Waste Incinerators

Impact of Medical Waste Incineration in the Atmospheric PCDD/F Levels of Porto, Portugal. (Coutinho et al. 2006)
Source of Funding: LIPOR (Intermunicipal Waste Management of Greater Porto), Portugal

The objective of the study was to evaluate the impact of two medical waste incinerators on the PCDD/F concentrations in ambient air. The incinerators located at the Hospital of S. João (HSJ) and the Hospital of S. António (HSA), have been in operation since the 1970's and were not equipped with any pollution control devices. Consequently stack emissions for HSA were 10 to 60 times higher than the EU PCDD/F TEQ limit, and HSJ emissions were three orders of magnitude above the EU PCDD/F TEQ limit. Both incinerators were shutdown in 2001 as a result of the implementation of the National Strategic Plan for Medical Wastes that regulates medical waste incinerator emissions.

To accomplish the study objective the researchers set up ambient air sampling sites within a 15 kilometer radius of both medical waste incinerators. Ambient air samples were collected every three months with high-volume air samplers equipped with filters for six years (five years with the facilities operating and one year with the facilities shutdown). PCDD/F concentrations were quantified using HRGC/HRMS.

> ***Relevance to Current Study***
> This article is not particularly relevant to the current study as it was a hazardous waste facility that lacked pollution control technology that would be employed in the contemplated EFW facility.

The researchers measured a reduction of approximately 50% in the atmospheric PCDD/F concentrations in both winter and summer after the closure of the two medical waste incinerators. The researchers concluded that the medical waste incinerators were a significant source of PCDD/F concentrations in the ambient air in Porto, Portugal.

Chemicals in Ambient Air surrounding a Biological Waste Incinerator in Charlotte North Carolina, United States. (Mukerjee et al. 1996)
Source of Funding: US EPA

Mukerjee et al. (1996) studied the emissions of fine fraction particulates, acid gas, and trace metals in ambient air from a biological waste incinerator in Charlotte, North Carolina, USA. Two incinerator units were in operation in 1992, one year prior to the installation of pollution abatement technologies. The goal of the monitoring program was to distinguish whether the installation of the pollution abatement technologies had any effect on the chemical emissions to the ambient air.

> ***Relevance to Current Study***
> Although this is a biological waste incinerator, the study emphasizes the effectiveness of pollution control technologies to mitigate detectable chemical concentrations in ambient air.

A versatile air sampler was set up at a location 850 meters south east of the incinerator stack and a control site was located 2 miles from the facility. The control location was determined not to be under the influence of the incinerator and be representative of background ambient air. Continuous air samples were taken for 12 hours every day for a month for the years 1992, 1993 and 1994. The researchers utilized principal components analysis to correlate the chemical levels in the atmosphere to the biological waste incinerator.

The authors reported that chemical concentrations from the biological waste incinerator were detectable in the sampling period for 1992. After the installation of pollution abatement technologies, chemical levels that were attributable to the incinerator were no longer detected.

Polychlorinated Biphenyls Near a Point Source Hazardous Waste Treatment Facility (Poon et al., 2005)

Source of Funding: Natural Sciences and Engineering Research Council of Canada (NSERC)

Relevance to Current Study
This article is not particularly relevant to the current study as it is a hazardous waste PCB facility. However, it does demonstrate that the highest concentrations of PCBs were found in close proximity (260m) of the facility.

Poon et al. (2005) investigated PCB emissions and ambient air concentrations surrounding a hazardous waste PCB treatment facility that began operations in Cornwall, Ontario in 1998. Ambient air samples of PCBs were collected 260 m northeast (downwind) of the facility. Two control sites were located greater than 4 km from the facility. An annual sample was collected at the air monitoring stations from 1999 to 2001; one year after the facility became operational. This program was conducted in conjunction with a vegetation monitoring program.

The hazardous waste facility was determined to have contributed to PCB concentrations in ambient air in close proximity to the facility. A decline in PCB concentrations with distance from the facility was reported.

3.2.2.5 Ambient Air Monitoring Program Summary

Study Team Finding
It is concluded from the scientific literature that an ongoing ambient air monitoring program would not be required for the proposed Durham/York EFW facility to ensure the protection of human or environmental health.

This conclusion was reached on the basis that no correlation was found between chemical concentrations in ambient air and stack emissions from facilities that employ modern pollution control technology.

The ambient air monitoring programs that passed the quality assessment framework all had similar characteristics in that they: 1) sampled ambient air in areas that were determined to be under the influence of a waste incinerator, 2) used reproducible sampling techniques that facilitated comparable results, and 3) used baseline or control data from similar areas to compare chemical concentrations.

The literature review determined that facilities that had upgraded or modern pollution control technology do not appear to be a significant source of chemicals detected in ambient air surrounding the incineration facility. However, older MWI facilities or hazardous waste facilities appear to in some cases have been a significant contributor to ambient levels of chemicals in the air surrounding these facilities.

The zone of potential influence of the facilities studied appears to be no greater than 2 km from the stack, with the majority of research focused in areas less than 0.5 km from the facilities. Baseline or control locations formed a critical part in all of the studies.

3.2.2.6 Soil Quality Monitoring Studies

In general, the soil monitoring programs included the analysis of chemicals in multiple soils samples, predominately located within the depositional zones of a waste incinerator and a comparison to either baseline or background samples. The techniques for gathering the soil samples varied between researchers, but in general, soil was usually collected from the upper 5 centimeters of the soil column. The most common chemicals analyzed were PCDD/F and metals.

3.2.2.7 Soil Quality Studies Surrounding Modern Municipal Waste Incinerators

No studies were retrieved in the systematic review that evaluated soil quality surrounding a modern incineration facility.

Relevance to Current Study
It is interesting that no results for soil sampling programs surrounding modern incinerators have been published in the primary literature.

3.2.2.8 Soil Quality Studies Surrounding Older Municipal Waste Incinerators

Effect of Incinerator emissions on soils in Spain and Brazil. (Schuhmacher et al., 1998; Segura-Munoz et al., 2004;)
Source of Funding: Catalonian Government, Barcelona, Spain, SIRUSA, FAPESP and CAPES

Two articles published by the Laboratory of Toxicology and Environmental Health, Rovira i Virgilli University, Spain (Schuhmacher et al., 1998; Segura-Munoz et al., 2004) studied the chemical concentrations in soils surrounding older municipal waste incinerators in Spain and Brazil (Table 3-5). Both studies were initiated as a result of heightened public concern over potential adverse health effects that may be attributed to incinerator emissions. Therefore, soil samples were collected surrounding the facilities to determine if MWI emissions had resulted in soil loading of PCDD/F and metals.

Meteorological data and atmospheric dispersion modeling were used to determine the zone of influence of the incinerator plume. Soil sample locations were selected based upon the maximum points of impingements. Collected soil samples were dried and sieved through a mesh screen to obtain a homogenized grain size and were stored in polyethylene bags until analysis. In all cases a control sampling site or baseline data were used to compare the chemical concentrations. Analytical methods included PCDD/F analyzed by HRGC/HRMS, ICP MS for As, Be, Cd, Ni, Pb Ba, Cu, Fe, and Mn, AAS for Cr, and cold vapor AAS for Hg. The quality assurance and quality control procedures were discussed in each article. Appropriate statistical tests were used to analyze each data set.

Relevance to Current Study
These studies demonstrated that facilities with older pollution control technology may have increased soil concentrations of chemicals emitted from the stack.

In Tarragona, Schumacher et al. (1998) reported that metal impacts in soil were localized to sample locations in close proximity to the MWI. This was an older incinerator and it was not equipped with modern pollution control technology. Segura-Munoz et al. (2004) found that with the closure of the MWI in Ribeirão Preto, Brazil, metals in soils decreased over sampling periods. The researchers surmised that a possible explanation for the reductions was the age of the incinerator and the limited pollution control devices installed.

TABLE 3-5 SUMMARY OF SOIL MONITORING STUDIES CONDUCTED BY THE LABORATORY OF TOXICOLOGY AND ENVIRONMENTAL HEALTH IN SPAIN

Reference	Location	Type of Incinerator	Start Date	Study Design	Key Conclusions	Funding
Schuhmacher et al., 1998	Tarragona, Spain	Municipal Waste	1991	24 soil samples were collected 250m, 500m, 750m, 1000m, 1500m, from the MWI stack. 10 Control samples were taken from rural area 4 – 6kms from the MWI	Researchers found that there was measurable but not statistically significant PCDD/F loading in soils in close proximity to the MWI.	SIRUSA
Segura-Munoz et al., 2004	Western Ribeirão Preto, Brazil	Municipal Waste	1989	32 soil samples were taken from 0-2000 meters along 4 transects N, E, W, and S 6 control samples were taken from a protected forest located 8 kms away from the MWI	The reductions in metal concentrations in the soil samples can be attributed to the closure of the MWI in 2002. Concentrations on Mn and V can be attributed to the landfill site located close to the sampling sites.	FAPESP and CAPES

Summary of Three Studies of Older Municipal Waste Incineration Facilities Where no Correlation to Soil Impacts was Reported

Three studies of older incineration facilities found no statistically significant correlation between incinerator emissions and chemical concentrations in soil (Sonich-Mullin, 1991; Caserini et al., 2004; Rimmer et al., 2006) (Table 3-6). The monitoring programs were borne from academic interest and public concern over potential health effects resulting from incinerator emissions.

Sampling locations were established within the deposition zone of influence of the facilities by using atmospheric dispersion modelling. Soil samples were dried and sieved through a mesh screen to obtain a homogenized grain size and were stored in polyethylene bags until analysis. In all cases a control sampling site or baseline data were used to compare the chemical concentrations. Analytical methods included PCDD/F analyzed by HRGC/HRMS, ICP MS for As, Be, Cd, Ni, Pb Ba, Cu, Fe, and Mn, AAS for Cr, and cold vapor AAS for Hg. The quality assurance and quality control procedures were discussed in each article. Appropriate statistical tests were used to analyze each data set.

In some cases improvements in pollution abatement technologies drastically reduced the incinerator stack emissions and therefore a correlation to the chemical levels in soils could not be found (Caserini et al., 2004). In other studies, sources of anthropogenic pollutants (other industry, automobile emissions, residential wood burning etc.) were found to have a more significant effect on pollution levels in the vicinity of the waste incinerators (Sonich-Mullin, 1991; Caserini et al., 2004).

Relevance to Current Study

These studies reiterate the importance of sampling within the modelled depositional zone of influence of MWIs.

It also demonstrates that MWI facilities may not impact soil quality in their surrounding area.

TABLE 3-6 SUMMARY OF INDIVIDUAL SOIL MONITORING STUDIES IDENTIFYING NO CORRELATION WITH INCINERATION FACILITIES

Reference	Location	Type of Incinerator	Start Date	Study Design	Key Conclusions	Funding
Caserini et al., 2004	Po Valley, Veneto Region, and Adige Valley Italy	3 Municipal waste incinerators	1998, 1983, 1994	S1: 750 meters – 5000 meters S2: 750 meters – 2000 meters S3: 1500 meters – 3000 meters	S1: not affecting PCDD/F concentrations in soil S2: MWI in addition to other industrial sources are affecting PCDD/F levels in soil S3: low PCDD/F levels in close proximity to the MWI	AEM Cremona, and the Municipality of Bolanzo
Rimmer et al., 2006	Newcastle upon Tyne, UK	Municipal Waste	1979	163 soil samples were taken at 4 transects (NE, SE, SW, NW) and at distances of 50 meters – 750 meters	Researchers concluded that the effect of the incinerator on soils with generally elevated metal concentrations could not be detected. Concentrations were typical to those found in urban areas.	Not Reported
Sonich-Mullin, 1991	Rutland, Vermont, USA	Municipal Waste	1987	60 soil samples were collected from areas that were in the depositional range of the MWI Soil samples were also collected prior to the operation of the incinerator as to establish a baseline	The measured pollutant concentrations could not be correlated with the emissions from the MWI. Therefore the incinerator was not found to be a point source of PCDD/Fs, metals and PCBs in the area.	Not Reported

Summary of Four Studies of Older Municipal Waste Incineration Facilities Where a Correlation to Soil Impacts was Reported

Five studies reported correlations between incinerator emissions and chemical concentrations in soil samples (Ohsaki et al., 1995; Collett et al., 1998; Caserini et al., 2004; Yan et al., 2008; Lorber et al., 1998) (Table 3-7). The monitoring programs were borne from academic interest and public concern over potential health effects that could manifest from incinerator emissions. Selection of sample locations and analytical methods were similar to those studies previously reviewed.

Two factors appear to have influenced soil contamination around these incineration sites.

1. The age of the incineration facility. Three of the five studies were for incineration facilities that had operational start dates in the 1980's (Ohsaki et al., 1995; Caserini et al., 2004; Lorber et al., 1998). These facilities were emitted higher chemical levels because of the limited technology available to control the pollutant levels emitted from the stack.
2. Distance from the incineration facility. As in the ambient air studies, there was a strong distance-decay effect of chemical concentrations in soil. In most of the studies it was reported that the greatest impacts in soil would be within the immediate vicinity of the MWI and typically no greater than <1km from the facility.

Relevance to Current Study
These studies reiterate the importance of sampling within the modelled depositional zone of influence of MWIs.
It also demonstrates that older MWI facilities may have impacted soil quality in their surrounding area.

TABLE 3-7 SUMMARY OF INDIVIDUAL SOIL MONITORING STUDIES IDENTIFYING A CORRELATION WITH INCINERATION FACILITIES

Reference	Location	Type of Incinerator	Start Date	Study Design	Key Conclusions	Funding
Caserini et al., 2004	Po Valley, Veneto Region, and Adige Valley Italy	3 Municipal waste incinerators	1998, 1983, 1994	S1: 750 meters – 5000 meters S2: 750 meters – 2000 meters S3: 1500 meters – 3000 meters	S1: not affecting PCDD/F concentrations in soil S2: MWI in addition to other industrial sources are affecting PCDD/F levels in soil S3: low PCDD/F levels in close proximity to the MWI	AEM Cremona, and the Municipality of Bolanzo
Lorber et al., 1998	Columbus, Ohio	Municipal Waste	1983	4 soils samples were taken from the incinerator property and 31 samples were taken outside the incinerator property. Control samples were taken 45kms away from the MWI	Soil concentrations declined from directly outside the incinerator property to the city at large.	Not Reported
Ohsaki et al., 1995	Fukuoka City, Japan	Municipal Waste	Prior to 1986	Soil samples were taken from a irrigation pond and a paddy field in the depositional ranges of the MWI A control sample was taken from an irrigation pond 10kms away from Fukuoka City	The MWI was determined to be a source of PCDD/Fs and Co-PCBs in the area. Co-PCB concentration decreased with an increase in the depth of the soil.	Not Reported
Collett et al., 1998	Dundee, Scotland	Municipal Waste	Not Reported	10 soil samples were collected 1km to 5 kms away from the incinerator Background soil was used but distance from the MWI was not elaborated.	The researchers concluded that atmospheric emissions of lead from the Baldovie incinerator significantly determines the local distribution of lead in soils within the immediate vicinity of the incinerator	Not Reported

3.2.2.9 Soil Quality Studies Surrounding Non-Municipal Waste Incinerators

Effect of Hazardous Waste Incinerator Emissions on Soils in Tarragona Spain (Nadal et al., 2005b; Ferre-Huguet et al., 2007)
Source of Funding: Catalonian Government, Barcelona, Spain, SIRUSA, FAPESP and CAPES

Two articles published by the Laboratory of Toxicology and Environmental Health, Rovira i Virgilli University, Spain (Nadal et al., 2005b; Ferre-Huguet et al., 2007) studied the chemical concentrations in soils surrounding a hazardous waste incinerator in Tarragona, Spain (Table 3-8). The monitoring programs were borne from academic interest and public concern over potential health effects resulting from incinerator emissions. Therefore, the researchers evaluated the concentrations of metals in soils surrounding the facility.

> ***Relevance to Current Study***
> This two event follow-up program of a modern hazardous waste incineration facility in Spain demonstrated that the facility had no impact on the surrounding soils.

Sample locations were selected in a similar manner to those already reviewed and the analysis procedures were the same.

40 soil samples were collected within eight kilometers of the facility and reported in 2005 and 2007. During both sampling events the low concentrations of metals in soils were attributed to other sources

of pollution in the area and not the hazardous waste incinerator. The researchers allude to the modern pollution control technology as being likely responsible for no deposition of metals to the surrounding area.

TABLE 3-8 SUMMARY OF SOIL MONITORING STUDIES CONDUCTED BY THE LABORATORY OF TOXICOLOGY AND ENVIRONMENTAL HEALTH IN SPAIN

Reference	Location	Type of Incinerator	Start Date	Study Design	Key Conclusions	Funding
Ferre-Huguet et al., 2007	Tarragona, Spain	Hazardous Waste	1999	40 soil samples were taken within 8kms from the HWI. A baseline study was used as a comparator	No significant correlation between levels of heavy metals and the HWI. In some cases the levels in soils decreased.	Agencia de Residus, Generalitat de Catalunya, Barcelona, Spain
Nadal et al., 2005b	Tarragona, Spain	Hazardous Waste	1999	40 soil samples were taken within 8kms from the HWI. A baseline study was used as a comparator	Fluctuations in the metal concentrations suggest that the influence of the HWI is minimal in relation to other metal pollution sources in the area.	Agencia de Residus, Generalitat de Catalunya, Barcelona, Spain

Summary of Four Studies of Non-Municipal Waste Incineration Facilities Where a Correlation to Soil Impacts was Reported

Soil sampling programs were carried out surrounding two older facilities that were used to incinerate chemical waste (Demond et al., 2008 and Jimenez et al., 1996), a sewage sludge incinerator (Feng & Barratt, 1999), and one modern facility in China (Yan et al., 2008) (Table 3-9). Again these programs were conducted either due to heightened public concern or by academic institutions. Note that the Chinese facility has been included in this section as its pollution control technology was not reported in the article. In all four articles there was a correlation between chemical emissions from the facility and soil concentrations.

Relevance to Current Study

These studies indicate that for hazardous waste facilities that were built prior to the late 1990s a correlation with chemical soil concentrations can be demonstrated.

It also emphasizes the importance of collection of soil samples within close proximity of a facility if one is attempting to attribute levels of contamination to the facility

In some cases anthropogenic pollutants (other industry, automobile emissions, residential wood burning etc.) were found to have a more significant effect on pollution levels in the vicinity of the waste incinerators (Jiménez et al., 1996; Feng & Barratt, 1999;). Researchers found that there was a strong distance-decay effect associated with the chemical concentrations. As the distance from the facility increased researchers could no longer directly and conclusively correlate soil concentrations of chemicals to the facility.

TABLE 3-9 SUMMARY OF INDIVIDUAL SOIL MONITORING STUDIES IDENTIFYING NO CORRELATION WITH INCINERATION FACILITIES

Reference	Location	Type of Incinerator	Start Date	Study Design	Key Conclusions	Funding
Jimenez et al., 1996	Madrid, Spain	Chemical Waste	Not Reported	14 soil samples were collected from 400m – 3000m from the waste incinerator 2 soil samples were collected 4.5 kms away from the incinerator and used as controls	PCDD/Fs found in the investigated surface soils indicated a slight contamination of these pollutants in the studied area. The analytical PCDD/F data and the distribution of homologue PCDD/F families and the 2,3,7,8, substituted congeners do not clarify whether the CWI plant is the only source responsible for PCDD/F levels found in the analyzed soils.	Not Reported
Feng & Barratt, 1999	Coleshill UK	Sewage Sludge incinerator	1976	22 surface ground dust samples were collected within a 4km radius of the waste incinerator 1 control samples was also collected though the location is uncertain	The study found little evidence that the incinerator would contribute to soil chemical concentrations. The highest Cd level was found about 2.2 km downwind of the prevailing wind direction from the incinerator, suggesting some another source of impact. Levels of Pb do not appear to be directly attributable to the incinerator. Overall the environmental impact of the incinerator is relatively small compared with that of other human activities in the area.	Not Reported
Demond et al., 2008	Midland, Michigan, USA	Chemical Waste Incinerator	1948 to 2003	2185 soil samples were collected in areas that were determined to be affected by the incinerator plume. 371 soil samples were collected as controls from neighbouring counties not affected by the incinerator emissions	Researchers found significantly elevated PCB and PCDD/F concentrations in the study area when compared to the control samples but failed to state whether they were directly correlated to the chemical waste incinerator. It seems to be assumed that the chemical levels were from the facility.	Not Reported
Yan et al., 2008	Hangzhou, China	Municipal waste incinerator Pollution Control Technology Unknown	2002-2003	30 soil samples were taken with a radius of 3kms from the MWI stack in the historical prevailing downwind directions.	MWI in addition to other sources of pollution (pesticides and a HWI) were the sources of PCDD/Fs in the area. PCDD/Fs attributable to the MWI were found to decrease with distance from the plant.	Not Reported

3.2.2.10 Soil Monitoring Program Summary

A number of articles published on older MWI, without modern pollution abatement technologies, reported a significant distance-decay effect associated with soil chemical concentrations and MWI facilities. Albeit that in many cases, influences by other anthropogenic sources as contributors to chemical concentrations found in soils could not be ruled out. However, there were also a number of scientific papers that showed no impact to local soil quality as a result of incinerator emissions.

Regardless, the soil monitoring programs all had similar characteristics in that they: 1) sampled soil in areas that were determined to be under the influence of a waste incinerator, 2) used reproducible sampling techniques that facilitated comparable results, and 3) used baseline or control data from similar areas to compare chemical concentrations

Perhaps the most significant finding was that soil sampling programs surrounding older facilities were most effective when samples were collected within close proximity (<1km) of facilities.

Study Team Finding
It is concluded from the scientific literature that an ongoing soil monitoring program would not be required for the proposed Durham/York EFW facility to ensure the protection of human or environmental health.
This conclusion was reached on the basis that a modern MWI that employs current pollution control technology should not impact local soil quality.

While a soil monitoring program may be beneficial in addressing public concern related to EFW facility emissions, a modern EFW facility equipped with the latest pollution control devices would be unlikely to have measurable changes in chemical concentrations in soils surrounding the facility. This is also supported by the deposition modeling that was completed in the Durham/York Residual Waste Study - Generic Risk Assessment, where soil loading concentrations at the maximum deposition location were predicted to be less than 1% of background levels.

3.2.2.11 Vegetation Monitoring Programs

In general, the vegetation monitoring programs included the analysis of chemicals in multiple vegetation samples, predominately located within the depositional zones of an incinerator and a comparison to either baseline or background samples. Vegetation samples were frequently collected and placed in aluminum foils and packed in polyethylene bags. To store the samples, researchers regularly dried the samples then packed them in double aluminum foils and froze them in temperatures ranging from -20^{o}C to -50^{o}C. The type of vegetation sampled varied from study to study and was heavily dependent on the type of vegetation available at the site. The quality assurance and quality control procedures were discussed in each article and appropriate statistical tests were used to analyze each data set.

The most common chemical concentrations quantified in vegetation samples were metals, PCDD/Fs, and PCBs.

3.2.2.12 Vegetation Quality Studies Surrounding Modern Municipal Waste Incinerators

No vegetation studies that passed the quality assurance for inclusion in the study were retrieved for modern MWI.

3.2.2.13 Vegetation Quality Studies Surrounding Older Municipal Waste Incinerators

Summary of Two Studies of Older Municipal Waste Incineration Facilities Where no Correlation to Vegetation Impacts were Reported

Two studies of older MWI did not report a significant correlation of chemical levels in vegetation to waste incineration practices (Sonich-Mullin, 1991; Misik et al., 2007) (Table 3-10). In the case of Misik et al. (2007), native plant species were collected surrounding the MWI. While Sonich-Mullin (1991) studied crops situated within one kilometer of the facility.

Relevance to Current Study
No correlation between older MWI facilities and vegetation concentrations were detected. This may have been a result of updated pollution control technology in one case.

As with the soil monitoring studies, there seemed to be no particular trend to suggest why these facilities did not result in significant chemical loading in analyzed vegetation samples. In the case of Misik et al. (1997) it is possible that improvements in pollution abatement technologies drastically reduced the emissions and therefore a correlation to the chemical levels in vegetation could not be found. The installation of modern pollution control technologies may explain why the operational start dates did not affect chemical levels in vegetation; as was the case with ambient air and soil monitoring programs.

TABLE 3-10 SUMMARY OF INDIVIDUAL VEGETATION MONITORING STUDIES IDENTIFYING NO CORRELATION WITH INCINERATION FACILITIES

Reference	Location	Type of Incinerator	Start Date	Study Design	Key Conclusions	Funding
Misik et al., 2007	Bratislava, Slovak Republic	Municipal Waste	In operation prior to 1997 it appears to have been retrofitted with updated pollution control technology between 2000-2004)	Wild plant species (chicory, old man's beard, common toadflax, greater celandine, flase acacia) were taken at approximately 150 meters from the MWI Control samples of the same species were collected from a rural area with low pollution levels in Western Slovakia at the same time a study group samples	In the first sampling period (1997-2000) significantly more abortive pollen grains were seen in the study group in comparison to the control group, whereas no significant effects were found in the second sampling period (2003-2005). This is explained by the implementation of an effective air filtration system in the MWI, and by use of new production techniques in the petrochemical plant. The genotoxic effects could be attributed to either the emission from the MWI or the petrochemical plant or a combination of both (likely the case)	Slovak Grant Agency
Sonich-Mullin, 1991	Rutland, Vermont, USA	Municipal Waste	1987	24 agricultural products (carrots, potatoes, milk, and grass hay) were samples less than 1 km from the MWI Baseline data was used as a comparator	The measured pollutant concentrations could not be correlated with the emissions or operation of the MWI. Evidence for this conclusion comes from both qualitative and quantitative evaluation of the measured pollutant concentrations in the ambient air and environmental media, as well as comparison with predicted ambient air concentrations of the pollutants using local meteorological information	Not Reported

Summary of Four Studies of Older Municipal Waste Incineration Facilities Where a Correlation to Vegetation Impacts were Reported

Four studies that passed the quality assessment framework reported significant correlations between incinerator chemical emissions and chemical concentrations in vegetation samples (Table 3-11) (Keller et al., 1994; Seike et al., 2005; Otani et al., 2006; Loppi et al., 2000). All samples were collected within 1 km of the MWI.

It appears that the incinerator age and pollution control technology had an influenced the chemical concentrations in vegetation. Additionally, distance-decay was also a factor in chemical concentrations in vegetation, as some studies found a decrease in vegetation chemical concentration with an increase in distance from

Relevance to Current Study
A correlation between older MWI facilities and vegetation concentrations were found within a kilometer of the facilities.

the waste incinerator (Keller et al., 1994; Blais et al., 2003; Loppi et al., 2000). Both of these findings are reoccurring trends in ambient air, soil and vegetation monitoring programs. In the case of the Japanese studies, they stated that significantly elevated chemical concentrations in vegetation could not be conclusively linked to incinerator emissions.

TABLE 3-11 SUMMARY OF INDIVIDUAL VEGETATION MONITORING STUDIES IDENTIFYING A CORRELATION WITH INCINERATION FACILITIES

Reference	Location	Type of Incinerator	Start Date	Study Design	Key Conclusions	Funding
Loppi et al., 2000	Poggibonizi, Italy	Municipal Waste	1996	5 thalli of the foliose lichen Parmelia caperata were sampled at 9 sampling sites located 50m - 1100 m from the incinerator. As a control 5 thalli of the foliose lichen Parmelia caperata were sampled at 3.5 and 10 kms from the incinerator, far from any local source of air pollution	Levels of Al, Cu and Hg were similar to those in unpolluted areas, whereas high values were found for Cr, Zn and especially Cd. The distribution pattern of the last three metals and the exponential relationship of their concentrations with distance from the incinerator, showed that the disposal plant is a local source of atmospheric pollution due to Cd, Cr and Zn.	Not Reported
Keller et al., 1994	Switzerland	Municipal Waste	1974	Beech foliage was collected from the upper canopy of beech trees 50 – 200 meters away from the MWI Baseline data was used as a comparator	The operation of the waste incinerator distinctly increased the chlorine concentration in the foliage. When the flue gas filtration did not work properly, several other elements also accumulated (Without any obvious dust accumulation). As distance from the MWI increased foliar accumulation decreased. A general decrease was seen in chemical concentrations over the years even though the amount of waste incinerator tripled.	Not Reported
Otani et al., 2006	Japan	Municipal Waste	Not Reported but appear to have been older facilities	Rice, Wheat, Soybean, Adzuki bean were sampled within 1 km from the MWI As a control Rice, Wheat, Soybean, Adzuki bean were sampled at least 1 km *away* from the MWI	Though soybeans showed a significantly higher ($p<0.05$) TEQ in the source area than the general area the authors could not conclusively state that the TEQ levels were directly attributable to the municipal waste incinerator	Not Reported
Seike et al., 2005	Japan	Municipal Waste	Not Reported but appear to have been older facilities	55 Fruit samples(apple, chestnut, grape, Japanese apricot, Mandarin orange, peach, pear, persimmon, pon-kan orange) were collected less than 1 km from the MWI As a control 102 fruit samples were collected >1km from the municipal waste incinerator	The TEQ of apples collected from near-source areas was significantly higher ($p<0.05$) than that collected from general areas. A PCA revealed that not only MWI's but also PCB's in the environment are associated with the elevated TEQ in apples.	Not Reported

3.2.2.14 Vegetation Quality Studies Surrounding Modern Non-Municipal Waste Incinerators

Effect of Hazardous Waste Incinerator Emissions on Chemical Levels in Vegetation in Spain
(Schuhmacher et al., 2002b; Bocio et al., 2005a; Nadal et al., 2005b; Ferre-Huguet et al., 2007)
<u>Source of Funding:</u> Catalonian Government

Four studies published by the laboratory of Toxicology and Environmental Health assessed chemical levels in vegetation surrounding a hazardous waste incinerator in Tarragona, Spain (Table 3-12) (Schuhmacher et al., 2002b; Bocio et al., 2005a; Nadal et al., 2005b; Ferre-Huguet et al., 2007). As with the soil monitoring programs the trigger for the initiation of a sampling program was heightened public concern over potential adverse health effects due to incinerator emissions. The chemical concentrations evaluated in the studies were PCDD/F and heavy metals.

> ***Relevance to Current Study***
> No correlation between chemical concentrations in vegetation and emissions from a modern hazardous waste facility were found. This is likely attributed to the modern pollution control technology in place at the time.

The researchers did not find any significant increases in chemical concentrations in vegetation resulting from the operation of the HWI in Tarragona Spain (Schuhmacher et al., 2002b; Bocio et al., 2005a; Ferre-Huguet et al., 2007). Only Nadal et al. (2005) found a significant increase in vegetation chemical concentrations, but they state that the increase was likely due to other sources emitting metals in the atmosphere. In addition, the researchers did not notice any notable distance decay in the chemical concentrations in vegetation samples (Schuhmacher et al., 2002b; Bocio et al., 2005a; Nadal et al., 2005b; Ferre-Huguet et al., 2007). This indicated that there were other anthropogenic sources of contamination in the area contributing the chemical concentrations in vegetation samples. With regard to human health from consumption of fruits, the researchers concluded absence of any measurable health impacts due to consumption of local fruits and vegetables in the local population based on local consumption patterns (Bocio et al., 2005a).

TABLE 3-12 SUMMARY OF VEGETATION MONITORING STUDIES CONDUCTED BY THE LABORATORY OF TOXICOLOGY AND ENVIRONMENTAL HEALTH IN SPAIN

Reference	Location	Type of Incinerator	Start Date	Study Design	Key Conclusions	Funding
Ferre-Huguet et al., 2007	Tarragona, Spain	Hazardous Waste	1999	40 samples were taken within 8kms from the HWI. Baseline data was used as a comparator	No significant correlation between levels of heavy metals and the HWI. In some cases the levels in soils decreased.	Agencia de Residus, Generalitat de Catalunya, Barcelona, Spain
Bocio et al., 2005a	Tarragona, Spain	Hazardous Waste	1999	Vegetables and Fruits were taken within the depositional ranges of the HWI from local gardens and produce markets. Vegetables and fruits were collected prior to the facility start up (baseline)	No notable differences between metal concentrations in current survey and baseline survey. Dietary intake of metals was not significantly changes from the baseline to the currently study. This shows the absence of a measurable health impact on the population.	Not Reported
Nadal et al., 2005b	Tarragona, Spain	Hazardous Waste	1999	40 vegetation samples (pipatherum paradoxum) were collected 5cm from the soil. A baseline survey was also conducted.	Fluctuations in the metal concentrations suggest that the influence of the HWI is minimal in relation to other metal pollution sources in the area. Cr, Mn, and V concentrations significantly increased. As levels	Agencia de Residus, Generalitat de Catalunya, Barcelona, Spain

Reference	Location	Type of Incinerator	Start Date	Study Design	Key Conclusions	Funding
					significantly decreased. All other metals showed no significant increase or decrease.	
Schuhmacher et al., 2002b	Tarragona, Spain	Hazardous Waste	1999	40 vegetation samples from urban and rural locations (actual locations not specified) were collected within 7kms from the incinerator Baseline data was used as a comparator.	There was a significant reduction in PCDD/F levels from 1996 to 1998. Small significant increase in PCDD/F level from 1998 to 2000 The study shows an absence of a notable PCDD/F contamination by the HWI in the area under its direct influence. Although the plant may have contributed locally to an increase in PCDD/F levels, the HWI is not the only source emitting atmospheric PCDD/F s in this area, and comparatively, its impact would not be notable.	Junta de Residus, Department of the Environment, Generalitat de Catalunya, Spain

PCB and PCDD/DF Congeners in Locally Grown Fruit and Vegetable Samples in Wales and England (Lovett et al., 1997)

Source of Funding: Welsh Office, UK

Lovett et al. (1997) conducted a study on apples, courgette, lettuce and potatoes collected within 1.5 km of a HWI in Panteg, UK. A suitable control group was established in areas devoted to arable farming or fruit and vegetable production, outside the zone of influence of industrial sources. There was no statistical difference in concentrations between produce grown locally within the zone of influence of the Panteg HWI and those from rural sites.

Relevance to Current Study
No correlation between chemical concentrations in vegetation and emissions from a hazardous waste facility were found within 1.5 km of the facility.

PCB Congeners in Native Vegetation Collected within Close Proximity to the Hazardous Waste Incinerator in Swan Hills, Alberta *(Blais et al., 2003)*

Source of Funding: Natural Sciences and Engineering Research Council

Between 1997 and 1998, Blais et al. (2003) studied the concentration of PCB congeners within 3 km of the hazardous waste incineration facility in Swan Hills, Alberta. White spruce needles and lichen growing on spruce trees was sampled, and a control site was located at a distance of 25 km and upwind of the facility.

Relevance to Current Study
The Swan Hills hazardous waste facility is much different than that being proposed by the Regions and the correlation to PCBs in vegetation is not likely to occur to the same extent in a modern MWI facility.

Within 3 km of the facility, there was correlation of higher chlorinated congeners of PCBs found within the spruce needles. These patterns varied seasonally and were attributed to influences of temperature effects on the volatilization of particle-bound and vapour phase PCBs in the forest canopy. The authors discussed that similar deposition patterns in snow suggest that the PCBs in the surrounding area were as a result of long-term fugitive releases of PCBs from the facility, rather than an accidental release.

3.2.2.15 Vegetation Monitoring Program Summary

The vegetation monitoring programs that passed the quality assessment framework all had similar characteristics in that they: 1) sampled vegetation in areas that were determined to be under the influence of a waste incinerator, 2) used reproducible sampling techniques that facilitated comparable results, and 3) used baseline or control data from similar areas to compare chemical concentrations.

In summary, vegetation monitoring programs further support the hypothesis that incinerators with poor pollution abatement technologies tend to have a more significant effect on chemical concentrations in environmental media (Keller et al., 1994; Blais et al., 2003; Misik et al., 2007). In addition the vegetation monitoring programs also found that there is a distance decay effect associated with chemical concentrations (Keller et al., 1994; Loppi et al., 2000; Blais et al., 2003).

It was also determined that samples, if collected, should be taken within a kilometer of a facility and only provide a good indicator of short-term chemical deposition from an EFW facility.

Study Team Finding
It is concluded from the scientific literature that an ongoing vegetation monitoring program would not be required for the proposed Durham/York EFW facility to ensure the protection of human or environmental health.

This conclusion was reached on the basis that a modern MWI that employs current pollution control technology should not impact local vegetation quality.

3.2.2.16 Agricultural Products Monitoring Programs

There were only a limited number of studies in the scientific literature that attempted to study the relationship between incineration facilities and potential effects on agricultural products.

The most common chemical concentrations quantified in samples were metals and PCDD/Fs.

3.2.2.17 Agricultural Product Studies Surrounding Modern Municipal Waste Incinerators

No agricultural product studies were retrieved for modern MWI.

3.2.2.18 Agricultural Product and Wildlife Monitoring Programs on Older Municipal Waste Incinerators

Four agricultural product studies that were conducted on facilities in operation prior to the late 1990s were included in the review (Liem et al., 1991; Eitzer, 1995; Ramos et al., 1997; Rumbold et al., 1997) (Table 3-13).

The agricultural product studies were conducted on facilities with older pollution control technology and may not be representative of levels that may be found surrounding facilities built after the late 1990s. The media sampled was agricultural meat (poultry or beef), dairy products, and chicken. In one study duck eggs were collected from close proximity to a MWI. Meat and egg samples were collected directly from farms located within the depositional ranges of a waste incinerator and directly transported to the laboratory for chemical analysis. Dairy products were also collected directly from farms using solvent cleansed glass bottles, oftentimes directly after the milking. Samples were frozen in the glass jars prior to analysis. Additionally, baseline or control samples were taken to evaluate the impact of a waste incinerator. PCDD/F, PCBs and metals were the most commonly quantified chemicals in fauna monitoring programs. This is likely due to the tendency for bioaccumulation and the potential risk of human health problems resulting from consumption of contaminated products.

The majority of the research studies were unable to find significant chemical concentrations in agricultural samples at levels that would adversely affect human health (consumption of the products) and ecological health (Eitzer, 1995; Ramos et al., 1997; Bocio et al., 2005a). Those locations that were assumed to be within in the depositional ranges of the incinerator, the measured chemical concentrations could not be conclusively linked to the facility (Rumbold et al., 1997).

Relevance to Current Study
The studies indicate that older MWI facilities could have a potential influence on agricultural products located within close proximity to the facility.

In the studies that reported significantly elevated chemical concentrations in agricultural products, the age of the incinerator and insufficient pollution control technologies were factors, which is a reoccurring trend in the environmental monitoring programs (Liem et al., 1991) . Distance decay also had an impact on chemical concentrations in fauna, as higher chemical levels were observed in agricultural products that were in very close proximity of a waste incineration facility (Liem et al., 1991).

TABLE 3-13 SUMMARY OF INDIVIDUAL AGRICULTURAL PRODUCT MONITORING STUDIES

Reference	Location	Type of Incinerator	Start Date	Study Design	Key Conclusions	Funding
Eitzer, 1995	Conneticut, USA	Municipal Waste	1992	12 bovine milk samples were collected from farms located between 2 and 8 miles from the incinerator. Baseline data was used as a comparator	Researchers observed no significant differences for any PCDD/F congener in bovine milk samples from the pre-operation and post-operational sampling programs	Not Reported
Liem et al., 1991	The Netherlands	Multiple Municipal Waste Incinerators	Not Reported	Bovine milk samples were taken in an area of 5x5km^2 NE from a MWI (approx. 200 in total). Control samples were taken from areas not within the depositional ranges of a MWI	In facilities with high dioxin emissions the concentrations of PCDD/F's in cow's milk significantly higher than the Dutch background level of 0.7-2.5 pg TEQ/g of fat. After the closure of 2 facilities with high dioxin emissions at the stack, the PCDD/F levels in cow's milk significantly decreased.	Not Reported
Ramos et al., 1997	Asturias, Northern Spain	Industrial and Municipal Waste	Not Reported	Bovine milk samples were collected from a farm located approximately 500 meters from the incinerators. Control bovine milk samples were collected from a farm located approximately 10kms from the incinerators.	PCDD/F levels on milk collected from rural areas were slightly lower than those collected from the MWI (3.32 and 2.04 pg I-TEQ/g fat). *Note: test of significance not conducted* The investigated cow's milk samples exhibited PCDD/F levels lower than 6 pg I-TEQs/g fat basis which is the limit value for human consumption in the legislation of certain EU countries	Not Reported
Rumbold et al., 1997	West Palm Beach, Florida, USA	Municipal Waste	Not Reported	Anhinga and White Ibis: 81 eggs, 79 nestlings were collected "next" (actual distance not given) to the MWI. Baseline data used as a comparator	No significant changes in TCDD, TCDF, As, Be, Cd, Ni and Hg were observed when compared to preoperational levels. Hg concentrations declined in the final year of operation. Concentrations of Pb in ibis nestlings were significantly higher in Year-1 and Year-5 compared to Year-0, but the MWI	Not Reported

Reference	Location	Type of Incinerator	Start Date	Study Design	Key Conclusions	Funding
					could neither be ruled out nor confirmed as the source of this lead.	

3.2.2.19 Agricultural Product Quality Studies Surrounding Non-Municipal Waste Incinerators

Two studies were conducted on hazardous waste incineration facilities and their potential influence on agricultural products (Bocio et al., 2005a and Lovett et al., 1998). (Table 3-12).

Bocio et al. (2005a), reported no significant increase in chemical concentrations in samples of meat, fish and seafood, whole milk, dairy products, eggs sampled within the depositional ranges of the facility, when compared to baseline (pre-operational period) levels of a modern hazardous waste incineration facility in Spain. In addition, they determined concentrations of metals were all below the World Health Organization (WHO) provisional tolerable weekly intake concentrations for the protection of human health.

Lovett et al. (1998), found significantly elevated levels of PCBs and PCDD/Fs in egg samples collected at a farm located within 70 m of an older hazardous waste incineration facility. This facility had been in operation since 1972 and at the time of sample collection had not undergone pollution control upgrades.

Relevance to Current Study
These studies indicate that the age of the hazardous waste incineration facility may affect the chemical concentrations in some agricultural products. It also indicates that samples should be taken in close proximity to the facility.

TABLE 3-14 SUMMARY OF INDIVIDUAL AGRICULTURAL PRODUCT MONITORING STUDIES

Reference	Location	Type of Incinerator	Start Date	Study Design	Key Conclusions	Funding
Bocio et al., 2005a	Tarragona, Spain	Hazardous Waste	1999	Meat, fish and seafood, whole milk, dairy products, eggs. were sampled within the depositional ranges of the facility Baseline data was used as a comparator.	There were no significant differences between metal concentrations in the current survey and baseline survey. This shows the absence of a measurable health impact on the population. For the most toxic elements (As, Cd, Hg and Pb) the concentrations were all under their Provisional Tolerable Weekly Intake established by the FAO/WHO.	Not Reported
Lovett et al., 1998	Panteg, UK	Hazardous Waste	1972	Eggs (chicken, bantam, and duck) and Duck meat samples were collected from 4 smallholdings in the Panteg district (near the HWI). Control samples of eggs (chicken, bantam, and duck) and duck meat were collected from 8 smallholdings in 3 rural areas.	Researchers observed that PCB and PCDD/F levels in egg samples collected from Pontyfelin House (located 70 meters from the HWI stack) were significantly higher than those found elsewhere in the Panteg district or at rural locations.	Welsh Office, UK

3.2.3 Human Biomonitoring of Residents

Twenty-five articles that involved human biomonitoring of residents living in the vicinity of an incineration facility passed the quality assurance check and were included in the study. Where multiple articles related to the same study, they were grouped and discussed as a comprehensive study. When reported by the author's the source of funding of each of the studies was included, so that any potential source of bias in the results would be readily evident.

3.2.3.1 Human Biomonitoring of Residents Living in the Vicinity of a Modern Municipal Waste Incinerator

Human Exposure to Heavy Metals and Dioxins in the Vicinity of Portuguese Solid Waste Incinerators - (Reis et al., 2007a; Reis et al., 2007b; Reis et al., 2007c; Reis et al., 2007d; Reis et al., 2007e)
Source of Funding: Lisbon - Valorsul S.A. (Facility Operator); Madeira Island - Regional Ministry of Environment and Natural Resources for the Autonomous Region of Madeira

Reis et al., of the Institute of Preventative Medicine at the University of Lisbon, published a series of 5 papers in 2007 that report findings of human biomonitoring studies in populations living near municipal waste incinerators in Portugal. Two incinerators were featured in this study – one in Lisbon operated since 1999 by Valorsul S.A., a public joint venture of five municipalities in the Lisbon Metropolitan Area North, and a second on Madeira Island, an older incinerator that was retrofitted and recommenced operations in 2002. Madeira Island is a small island in the Atlantic located well off the coasts of Portugal and Morocco.

The purpose of these studies was to assess human exposure to heavy metals and dioxins as a result of residing near a municipal waste incineration facility. Concentrations of PCDD/F, lead, mercury and cadmium were measured in the blood of healthy adults. The concentration of dioxins in maternal breast milk, as well as lead in the umbilical cord blood and blood of children was also measured. All studies included a control group, and in the case of metal studies, a baseline and temporal measurements were included. The control group participants were located at a minimum of 3-20 km from the incinerator, depending on the study. Typical participant sizes ranged from 30-135 participants per study group, in each region. All participants were volunteers and provided written informed consent to participate. Participants in the study and control groups were matched for socio-demographic characteristics. A health measures questionnaire was administered to all participants to collect data on individual characteristics such as dietary habits, smoking, drinking, occupation, and other socioeconomic factors. Analysis for PCDD/F was conducted by gas chromatography/mass spectrometry and analysis for heavy metals was conducted by atomic absorption spectrometry.

Some statistically significant differences in the blood lead levels of children were observed between the study and control groups. However, where differences were observed, the concentrations observed in the study group were not always higher than those in the control group. In fact, in Lisbon, the study group was observed to have decreasing lead levels over time while the control group was observed to have increasing lead levels. The study also noted that 3% of the children in the entire study (study or control group) were observed to have lead levels above the United States Centers for Disease Control and Prevention (CDC) action level of 10 µg/dl. As a result of these unclear trends, the authors concluded for this chemical that further study was warranted to clarify the trend and any contribution of the incinerator emissions to the identified lead levels.

In all studies conducted, residents of urban Lisbon (whether in the study or control group) were observed to have significantly higher levels of PCDD/F and heavy metals than residents of the more rural Madeira Island. This trend was deemed to be most likely associated with the generally increased levels of pollution associated with urban areas. In both the study and control groups, in the general adult population and in the breast milk of lactating women, no significant differences were found in PCDD/F levels. Study results showed that levels of lead, cadmium and mercury in the general population, and levels of lead in the umbilical cord blood were not significantly different between the study and control groups. Where differences did occur, the authors deemed them to be so small as to be irrelevant from a health point of view. The authors also noted a generally significant trend for the reduction of these metal levels in the populations studied over time. The overall conclusion of the authors is that the results suggest the effectiveness of source control measures at both MWI facilities.

Relevance to Current Study
This is the most comprehensive study of human biomonitoring surrounding modern MWI facilities reported in the literature.

No statistical increase in chemical concentrations was found that could be attributed to the MWI facilities.

Appropriate statistical tests were used to analyze the data in this study. The fact that all the participants were volunteers is recognized as a potential source of study bias. The authors commented throughout on the difficulties encountered in participant recruitment, particularly the "*enormous difficulty in recruitment and sample collection from children*". Dr. Reis also agreed to participate in our external expert contact survey, the results of which are provided in Section 5.

Dioxin Exposure to Residents Living Near Municipal Waste Incinerators in Taiwan - (Chen et al., 2003; Chen et al., 2004; Lee et al., 2005)
Source of Funding: Taiwan Environmental Protection Administration

Three studies were identified from the Department of Environmental and Occupational Health at the National Cheng Kung University in Taiwan (Chen et al., 2003; Chen et al., 2004; Lee et al., 2005) for inclusion in the study. The papers focus on a selection of municipal waste incinerators in Northern Taiwan, and attempt to determine the degree to which residents living near the facility are exposed to chemicals emanating from the facility.

Chen et al., (2003) studied three incinerators in operation for approximately 7 years, as well as one which had yet to be operated at the time of the study. This fourth incinerator, that which had yet to be operated, served as the control group for the study. 341 participants were recruited by the study authors based on the sex ratio in each area – all having lived within 5 km of one of the incinerator locations for at least 4 years. All residents were adult and a 50:50 ratio of males and females was obtained. These participants were sampled for PCDD/Fs in blood serum. Gas chromatography/mass spectrometry was used for analysis of serum samples. A socio-demographic characteristics questionnaire was administered by trained interviewers to all participants to collect information that could assist in the identification of confounding factors. The researchers observed no statistical differences in PCDD/F levels between residents at the four locations. The highest values observed were seen in the control group, at the site of the incinerator which had yet to commence operations.

The researchers also observed significantly higher concentrations of PCDD/Fs in females, smokers and older residents, although reasons for these differences were not explained.

Chen et al., (2004) assessed PCDD/F levels in the blood serum of 95 recruited participants living, for at least 5 years, within 5 km of a single municipal waste incinerator in Northern Taiwan, which had been in operation for more than 6 years at the time of the study. Air dispersion modeling was conducted to identify four (4) zones of varying PCDD/F concentrations, including one background zone which was predicted to have minimal dioxin emissions. The number of participants and sex ratio of participants in each zone was not significantly different. Some significant differences existed within the age distribution of each zone. 82% of all study subjects were older than 35. Similar to the previous study (Chen et al., 2003), gas chromatography/mass spectrometry was used for analysis of serum samples. A socio-demographic characteristics questionnaire was administered by trained interviewers to all participants to collect information that could assist in the identification of confounding factors. The study found no statistically significant differences between serum concentrations of PCDD/F across the four zones. Furthermore, the authors found no correlation between the predicted ambient air concentrations and the biological levels of PCDD/F. The authors postulated that "ambient exposure was thus not the single most important contributor to serum concentrations when compared to other sources of exposure such as dietary intake". Similar to the previous study (Chen et al., 2003), higher levels of PCDD/F were found in females, although no correlation was identified between PCDD/F levels and age.

Relevance to Current Study

No causal link between the MWI facility emissions of PCDD/F was found in residents living within the vicinity of the facilities.

This study emphasized the need for a control group, or baseline assessment to compare results from those residents living near a modern MWI facility.

In order to further test the ambient air model used in the previous study, (Lee et al., 2005) carried out a follow-up study on the same incinerator, and collected 16 ambient air samples to further test the observed results obtained by (Chen et al., 2004). No statistically significant differences were observed with respect to the ambient air concentrations of PCDD/F in the four zones. With the exception of a single PCDD/F congener, no statistical relationship was observed between ambient air and serum measurements. The authors conclude that people living in the vicinity of a source of PCDD/F emissions will not necessarily accumulate emitted atmospheric PCDD/Fs in their serum. Seasonal sampling identified that PCDD/F concentrations in ambient air dropped by a factor of 10 when the incinerator was shut down. The particular season in which this shut-down occurred was not specified by the authors. This led to the conclusion that "*ambient exposure was the most important contributor to PCDD/F levels in ambient (air) but not the single (most important contributor) in serum, and another or more powerful source, such as occupational exposure, the consumption of local food, (and) dietary intake should be further investigated at the same time*".

Appropriate statistical tests were used for all data analysis. The authors identified the small number of ambient air samples as a limitation of the study, potentially reducing the overall power of the ambient air analysis.

Internal Exposure to Pollutants Measured in Blood and Urine of Flemish Adolescents in Function of Area of Residence - (Schroijen et al., 2008)
Source of Funding: Ministry of the Flemish Community

This paper summarizes the results of a regional human biomonitoring campaign of adolescents in Flanders, a region in Northern Belgium. A cross-sectional study design was adopted for this purpose that investigated potential exposure to a host of industrial conditions. Adolescents from a number of different study groups were assessed, among them a group of 207 participants, aged 13-16, having resided at least 5 years in the immediate surroundings of municipal waste incinerators. The remainder of the study outlined the results found in 1472 similar children from various parts of the region – for the purpose of this discussion, these participants serve as the control group. Study group participants were recruited by mail based on residence near waste incineration facility. Control group participants were recruited by written invitation at over 50 schools throughout the region. Both the adolescents and their parents completed self-reporting questionnaires on personal and lifestyle factors.

Relevance to Current Study
Although this study had a larger focus than biomonitoring surrounding MWI facilities, the authors reported no statistical difference in chemical concentrations in children living near a MWI compared to the reference mean of the entire study.
Some regional differences were noted but could not be attributed to MWI facilities.

Metals (lead and cadmium), PCBs, chlorinated pesticides (DDE and HCB), and markers of PAH and benzene exposure (1-hydroxypyrene and t,t'-muconic acid) in blood and urine were the focus of the study. The authors observed no statistically significant differences between mean values of all chemicals analyzed in children living near the waste incinerators as compared to the reference mean for the entire study. The authors further expanded on the incinerator results by assessing exposure levels of all chemicals analyzed at each of the six incineration facilities studied. Some individual differences existed between the observed and reference means (i.e. significantly higher lead levels in Wilrijk, significantly lower cadmium levels in Ghent, etc.). Overall, for the seven parameters assessed, the results showed five instances where levels were significantly higher, 7 instances where levels were significantly lower and 30 instances where no significant difference was observed between the observed levels and the reference mean. Further, the authors identified that residents of small areas (i.e. surface area of less than 10 km^2) around a point source such as an incinerator may show significant increases in internal exposure, however, specific data was not provided to support this statement. The authors concluded that the results of the overall study were in line with results from previous local and international studies.

Serum Levels of PCDDs, PCDFs and PCBs in Non-occupationally Exposed Population Groups Living Near Two Incineration Plants in Tuscany, Italy - (De Felip E. et al., 2008)
Source of Funding: Provincia di Grosseto (local government) and Fondazione Monte dei Paschi di Siena

Due to public concern over the exposure of residents to two MWI facilities, the local government was prompted to conduct a human biomonitoring study in the areas of concern. Serum levels of PCDD/Fs and PCBs in 35 residents living within 5 km of a facility for at least 20 years were compared to 39 residents living at a minimum of 5 km from a facility for at least 20 years. The first incinerator burned municipal solid waste, and occasionally sanitary waste, from 1976 to 2000. The second burned municipal solid waste and waste wood between 1997 and 2003, and since that point has burned "clean" wood. Participants were enrolled through the local health authorities after providing informed written consent. A self-administered questionnaire on lifestyle and personal factors was also administered.

The authors found no statistically significant differences in serum levels of PCDD/F and PCB between the study and control groups. The authors noted that those older than 55 demonstrated higher levels than those below that age, consistent with the theory that body burden is age dependant. The authors concluded that the study *"did not provide evidence of a significant increase in PCDD and PCDF body burden in subjects living in the vicinity of incineration plants, in the absence of a regular consumption of local animal product"*. The authors added this condition to the closing statement due to the finding that participants in the study were not found to consume significant amounts of local animal products, and previous studies which have shown increases have attributed this exposure to the intake of locally produced food.

Relevance to Current Study
This biomonitoring study did not establish a causal link between MWI facility emissions of organic contaminants and serum levels of those people living in the vicinity.

3.2.3.2 Human Biomonitoring of Residents Living in the Vicinity of an Older Municipal Waste Incinerator

Accumulation of PCDD/Fs and Heavy Metals in Residents around Belgian Municipal Waste Incinerators - (Fierens et al., 2003; Fierens et al., 2007)
Source of Funding: Ministry of the Environment of Walloon Region

Fierens et al., of the Université Catholique de Louvain in Belgium, investigated whether PCDD/Fs, PCBs, and metals (cadmium, mercury and lead) emitted by older MWI facilities increased the contaminant body burden of residents living near the facilities in Belgium. To achieve this, the authors conducted a cross-sectional study in which blood and urine was sampled and analyzed for PCDD/F and metals. Eighty-four participants living within 2 km of two municipal waste incinerators, for an average of 18 years, were compared to concentrations in 63 residents of an unpolluted rural area. All participants were adult volunteers and were recruited by mail. Targeted residents included those with long residence times and regular consumption of locally produced foods. Dietary information was gathered through a self-administered questionnaire. PCDD/F concentrations in serum fat from fasting blood samples were determined by gas chromatography/high resolution mass spectrometry.

The incinerators began operations in 1978 and 1980 and were located in an industrial (33 participants) and a rural area (51 participants), respectively. Until the release of the European Union (EU) Directive on Incineration Emissions, these incinerators released dioxins at levels 500 times above the current regulatory EU limit.

The authors reported that participants who lived around the rural incinerator had dioxin and cPCB concentrations that were 50% higher than the controls, a difference that was statistically significant. The PCDD/F and cPCB levels of participants who lived around the industrial incinerator were similar to those of the control subjects. The authors attributed this result to a greater consumption of locally produced foods in rural areas (particularly bovine and poultry products), confirmed by similarities observed between the congener profile found in local cow's milk and the emissions of the rural facility. A positive correlation was also identified between PCDD/F and cPCB levels and age, as well as cPCB levels and body mass index. No significant differences were observed in the concentrations of metals between those living near incinerators and the control group. The authors also estimated that "*a 10% rise in body burden is likely to occur only when dioxin emissions exceed 5 ng TEQ/Nm^3, a threshold largely above emissions standards currently in force in most countries (between 0.1 and 1 ng TEQ/Nm^3)*". The authors concluded that the differences observed could be attributed to dietary intake and that the local food chain can enhance exposure.

Relevance to Current Study
The authors highlight the importance that dietary intake of agricultural products surrounding older MWI facilities may play in PCDD/F and PCB exposure for rural residents. This finding is based on a greater than 500 fold emission of PCDD/F from the MWI facility than currently allowed by the EU.

Appropriate statistical tests were used to analyze the data. The major bias in this study was that all participants were volunteers and therefore self selection could have biased the results.

Environmental Tobacco Smoke Interference in the Assessment of the Health Impact of a Municipal Waste Incinerator on Children Through Urinary Thioether Assay - (Ardevol et al., 1999)
Source of Funding: Pharmaceutical College of Barcelona

The authors sought to assess the impact of exposure to waste incinerator emissions to the urinary thioether profiles of urban children. Two groups of children aged 7-10 were studied: 39 children living near a municipal waste incinerator in Mataró, Spain, and 44 children living far away from the facility. Participants were recruited through two schools, with parental permission. Parents were also asked to ensure that the participants followed a specific diet void of certain foods for 48 hours prior to sampling. During sampling, participants were interviewed on location of residence, medications taken and exposure to smoke in the home.

Relevance to Current Study
The study highlights the importance of considering confounding factors in the interpretation of results. Factors such as exposure to cigarette smoke can significantly alter the final conclusions of a study.

Urinary thioethers are considered good indicators of exposure to polycyclic aromatic hydrocarbons (PAHs). The authors found that although the study group tended to have higher values of urinary thioethers, the differences between the study and control groups were not statistically significant. The study further identified significantly higher levels in children exposed to tobacco smoke compared to those not exposed, confirming cigarette smoke as a potential confounding factor in the evaluation of chemical levels and proximity to incineration facilities.

Correlation Coefficients Between the Dioxin Levels in Mother's Milk and the Distances to the Nearest Waste Incinerator which has the Largest Source of Dioxins from Each Mother's Place of Residence in Tokyo, Japan - (Tajimi et al., 2005)
Source of Funding: Not specified by authors.

The authors assessed PCDD/F and co-PCB levels in breast milk of 240 women in relation to the residential distance of the mother from the nearest municipal or industrial waste incinerator. Included women lived at a range of 0-11 km from the incinerator for a minimum of 5 years. Incineration facilities are quite common in Japan, with some people living within 2-3 km of 50-75 incineration facilities. All participants self-reported on a questionnaire focused on factors such as age, history of delivery, tobacco smoking, and consumption of locally grown produce and seafood. Occupational exposure to the analyzed chemicals was not assessed and is a source of potential bias in this study.

Although some correlation was found with respect to the levels of individual PCDD/F or co-PCB congeners, the authors found no significant correlation between the mean TEQ levels and the distance from the incinerator. Where correlations did exist with respect to individual congeners, they were such that concentrations increased as the distance from the incinerator was increased, indicating a negative correlation between dioxin levels in breast milk and residence near the incinerator. Significant correlations were also observed with respect to age (positive correlation), and number of children mothered (negative correlation).

Relevance to Current Study
This study did not establishing a causal link between emissions of PCDD/F from incinerators and monitored human breast milk levels.

3.2.3.3 Human Biomonitoring of Residents Living in the Vicinity of Non-Municipal Waste Incinerators

Impact of a Hazardous Waste Incinerator on Nearby Residents of Tarragona, Spain - (Granero et al., 1998; Llobet et al., 1998; Schuhmacher et al., 1999a; Schuhmacher et al., 1999b; Schuhmacher et al., 2004a; Schuhmacher et al., 2004b; Agramunt et al., 2005; Nadal et al., 2005a; Bocio et al., 2005b; Schuhmacher et al., 2007; Nadal et al., 2008)
Source of Funding: Catalonian Government

The study group led by Dr. J.L. Domingo at the Laboratory of Toxicology and Environmental Health at Rovira i Virgili University, published 11 papers on the topic of human biomonitoring of residents living near incineration facilities. Four of these papers failed to pass the quality assessment framework due to the lack of specification of whether or not a socioeconomic characteristics questionnaire was administered to participants (Granero et al., 1998; Schuhmacher et al., 1999b; Agramunt et al., 2005; Nadal et al., 2008). Such a questionnaire is critical for the identification of confounding factors in the analysis of results. Three (3) of these four (4) papers described the sampling of PCDD/F levels in the blood of the general population. As a result of this missing information, and inherent uncertainty over the consideration of confounding factors, this study has not been described in the following text.

The focus of study for all the above mentioned papers is a hazardous waste incinerator in Tarragona, Spain which began regular operations in 1999. The biological monitoring program samples human blood, hair, autopsy tissues, adipose tissues, and breast milk, although rationale for inclusion of each of the tissues was not included by the authors. A longitudinal, cross-sectional study design was implemented for this purpose. This program was initiated and is supported by the Catalonian government in response to public concern over the potential for human exposure to chemicals emanating from the facility (personal communication, J.L. Domingo, see section 5.4.3.2).

Baseline sampling of the aforementioned tissues was conducted during facility construction. Sample sizes range from 15 lactating mothers that provided breast milk to 134 school children for hair sampling. Follow-up studies were conducted for each medium sampled at approximately 4 year intervals. Though control groups of residents far from the facility were not used in this study, the use of a baseline is an alternate method of comparing results and potential exposure related to incinerator emissions. Results obtained in follow-up studies can be compared to results in the same location obtained prior to the installation of the facility. This method of conducting longitudinal sampling quantifies the potential specific facility-associated exposure.

Relevance to Current Study
This is the most comprehensive study of human biomonitoring surrounding modern hazardous waste incineration facilities reported in the literature.

No statistical increase in chemical concentrations was found that could be attributed to the facilities.

Study results indicate that there was no identifiable correlation between chemical levels in biological samples and proximity of people living near the hazardous waste incinerator. For most tissues sampled, an overall decrease in chemical levels was observed over time. Dr. Domingo also agreed to participate in our external expert contact survey, the results of which are provided in Section 5.

Influence of an Industrial Waste Incinerator on Dioxin Levels in Residents in Korea - (Park et al., 2004) and (Leem et al., 2006)
Funding Source: Korean Ministry of the Environment

The authors used a cross-sectional study design to assess the influence of an older industrial waste incinerator on the soil and residents near the facility. The authors assessed blood levels of PCDD/Fs in 40 residents living within 5 km of an industrial incinerator in Korea which operated from 1998 to 2001, as compared to a control group of 20 residents living at least 20 km from the incinerator. Both of these population groups were then compared to results from 5 residents of an agricultural area with no industrial activity. All participants were over the age of 20 and had lived in the same residence for at least 5 years. A health survey was conducted with all participants concerning variables deemed potentially influential to the PCDD/F blood levels, such as age, gender and occupation. It should be noted that based on emissions measurements made in 2000 and 2001, the authors report that the average concentration of PCDD/Fs emitted from the stack were over 100 times greater than the currently regulated level in the European Union Directive on Incineration or the Guideline A-7 in Ontario.

Soil sampling at 47 locations was also conducted, with locations determined with the assistance of an emissions dispersion model. PCDD/F concentrations in soil showed no particular dependence on wind direction. Although soil concentrations between 0-100 m from the incinerator appeared to demonstrate a decreasing gradient as distance from the facility increased, this gradient disappeared at 100 m and no significant trend could be observed beyond the 100 m mark, up to 12 km from the facility.

With regard to PCDD/F levels in human blood, although the total mass concentration of PCDD/Fs was greater in the control group, no statistically significant difference was observed between the I-TEQ of residents in the study and control groups. The I-TEQ is a collective measure of PCDD/F based on relative toxicity. The authors did however note that of the 7 participants displaying the highest I-TEQ values, 5 of those participants lived within 0.5 km of the incinerator. Compared to the agricultural area, levels in both the study and control groups were generally higher. No statistical comparison was made due to the small sample size of the agricultural area.

Relevance to Current Study
This study was conducted on an industrial waste incinerator that emitted greater than 100 times the allowable PCDD/F concentration from the stack as permitted by the EU or Ontario MOE.

A statistical correlation between some of the emitted PCDD/F congeners was reported, although the overall I-TEQ of PCDD/F was not statistically different.

The authors did attempt to demonstrate the influence of the incinerator by noting that congener patterns observed in soils and blood near the incinerator were similar, and based on principal component analysis, were statistically different from the pattern observed in the control group. Certain risk factors were also identified to be significantly correlated with PCDD/F concentrations. Levels were found to increase with age and duration of residence. Smokers were found to have higher levels in their blood, as were farmers and individuals eating a large amount of fresh water fish.

Appropriate statistical tests were used for all data analysis however the sample size of the agricultural control group did not allow for statistical comparisons to be made. This limits the conclusions that can be made with regard to this particular group.

Increased Mercury Exposure in Inhabitants Living in the Vicinity of a Hazardous Waste Incinerator: A 10-Year Follow-Up - (Kurttio et al., 1998)
Source of Funding: National Public Health Institute

The authors investigated the exposure of residents living near a hazardous waste incinerator in Finland to mercury, 10 years after the commencement of incinerator operation. Mercury levels in the hair of 11 workers and 113 residents living within 5 km of the facility were analyzed. All the participants had previously participated in a baseline study prior to the commencement of operations – these participants represented 42% of the original baseline which consisted of a total of 431 participants. The results were compared to levels found in a control group of 55 residents from a town 30 km away from the incinerator. The authors observed an "*increase in mercury exposure among workers…and among those who lived near the plant. Nonetheless, the increases were small and in accordance with present knowledge, they reflect exposure levels that do not produce adverse health effects*."

Relevance to Current Study
This study observed an increase in mercury hair concentrations in residents living near an older hazardous waste incinerator. However, the increases were small and would not produce adverse health effects.

Dioxin Incinerator Emissions Exposure Study, Times Beach, Missouri - (Evans et al., 2000)
Source of Funding: Missouri Department of Health and the Agency for Toxic Substances and Disease Registry

The authors investigated the exposure of residents living in the vicinity of a hazardous waste incinerator, burning soil and other PCDD/F contaminated materials in Times Beach, Missouri. The authors designed a prospective cohort evaluation study, in which participants were randomly selected from areas that air modeling exercises predicted would be highly exposed to dioxins, within a 4km radius of the facility. Census data for Missouri was used to identify comparison areas which were similar to the study group 15km from the facility. Random sampling of names was conducted and potential participants in both the study and control group were contacted and interviewed for eligibility. Based on the results of a power analysis, 75 residents from each group were sought. Sixty-seven and 61 participants in each of the study and control groups completed the entire year-long study. An interview administered questionnaire was used to obtain information on demographics, occupation and behaviors that could be associated with PCDD/F exposure. Dioxin concentrations in serum fat from fasting blood samples were determined prior to incineration, four months after incineration began and immediately after cessation of incineration, 11 months after the start of the study, by the US Centers for Disease Control and Prevention (US CDC).

Relevance to Current Study

This study did not establishing a causal link between emissions of PCDD/F from a modern hazardous waste incineration facility and monitored human blood serum levels.

The authors identified no statistically significant increases in 3,2,7,8-TCDD or its TEQ in either the study or control groups over the length of the study. Rather, in both groups, a significant decrease in 2,3,7,8-TCDD and its TEQ was noted over time. The authors also did not identify any statistically significant differences between TCDD or TEQ levels in the study group with respect to the control group. They also identified a positive correlation between dioxin levels and age, as well as a significant difference in TEQ levels between those exposed to cigarette smoke in the home and those not exposed. The authors conclude that the incineration activities did not result in any measurable dioxin exposure to the population surrounding the incinerator.

Appropriate statistical tests were used to analyze the data. As identified by the authors, the ability of the study to extrapolate results to other facilities is limited by the participant selection criteria, which was quite stringent, though this enhanced the validity of the study itself.

3.2.3.4 Overall Summary of Human Biomonitoring Studies

In summary, the results of the systematic review of the scientific published literature indicate that there is not a significant relationship between exposure to chemical emissions from incinerator and measured chemical levels in human media such as blood, urine, breast milk and hair. With regard to PCDD/Fs, the most commonly referenced chemical assessed in the studies, authors noted occasional differences in individual PCDD/F congeners and measured samples. Congener analysis can be important as it may be possible to correlate a particular individual congener emitted from an EFW facility to those found in exposed residents. However, no two congeners are the same, and some are more or less toxic than others. The toxic equivalent (TEQ) is thus a useful measure, as it provides a single, cumulative number based on the relative toxicity of each congener.

The only study to identify significantly elevated PCDD/F TEQ levels in humans were Fierens et al., 2003; Fierens et al., 2007, which identified this trend in residents of a rural area containing an older municipal waste incinerator, which for nearly 20 years emitted dioxins at levels 500 times greater than the current emissions limit in the European Union or the Ontario Guideline A-7 allowable limits. These emissions levels resulted in high levels of PCDD/Fs in the local environment, which was then transferred to the local residents in the form of dietary intake, as this rural population ingested a large amount of local dairy and livestock.

Study Team Finding

It is concluded from the scientific literature that an ongoing human monitoring program would not be required for the proposed Durham/York EFW facility to ensure the protection of human or environmental health.

This conclusion was reached on the basis that there was no correlation between chemicals emitted from modern MWI facilities and those measured in the human biomonitoring programs.

A summary of the literature review is provided in Table 3-15.

TABLE 3-15 SUMMARY OF HUMAN BIOMONITORING STUDIES CONDUCTED SURROUNDING INCINERATION FACILITIES

Reference	Location	Type of Incinerator	Start Date	Sampling Methodology	Key Conclusions	Funding
Modern MWI Facilities						
Reis et al., 2007a; Reis et al., 2007b; Reis et al., 2007c; Reis et al., 2007d; Reis et al., 2007e	Lisbon and Madeira Island, Portugal	Municipal Waste	1999/2002	Assessment includes PCDD/Fs, lead, mercury, and cadmium in blood of healthy adults, PCDD/Fs in maternal breast milk, lead in umbilical cord blood and blood of children.	Some statistically significant differences in blood lead levels of children, however, concentrations not always higher in study group. General significant trend for the reduction of other parameters over time, suggesting the effectiveness of source control measures.	Lisbon – Facility Operator; Madeira Island – Regional Ministry of the Environment
Chen et al., 2003; Chen et al., 2004; Lee et al., 2005;	Northern Taiwan	Municipal Waste	Mid-to-Late 1990's	PCDD/Fs in blood serum of adults.	No statistically significant differences between residents in four zones of varying exposure, including a background zone.	Taiwan Environmental Protection Administration
Schroijen et al., 2008	Belgium	Municipal Waste	Not Reported	Metals, PCBs, Pesticides, and markers of PAH and benzene exposure in blood and urine	No statistically significant differences between mean values as compared to reference mean for nationwide study.	Ministry of the Flemish Community

Reference	Location	Type of Incinerator	Start Date	Sampling Methodology	Key Conclusions	Funding
				of children.		
De Felip E. et al., 2008	Tuscany, Italy	Municipal Waste and Wood	1976-2000; 1997	PCDD/Fs and PCBs in blood serum of adults.	No statistically significant differences in serum levels of PCDD/Fs and PCBs between study and control groups.	Provincia di Grosseto (local government) and Fondazione Monte dei Paschi di Siena
Older MWI Facilities						
Fierens et al., 2003; Fierens et al., 2007	Belgium	Municipal Waste	1978/1980	PCDD/Fs, PCBs and metals in blood serum and urine of adults.	PCDD/F and PCB concentrations were higher in rural study group compared to controls. The difference was statistically significant. No such difference was observed for the industrial area study group. No differences were observed with regards to metal concentrations.	Ministry of the Environment of Walloon Region
Ardevol et al., 1999	Mataró, Spain	Municipal Waste	1995	Urinary thioethers (marker of PAH exposure) in children.	Differences between study and control groups were not statistically significant, though study group levels were higher.	Pharmaceutical College of Barcelona
Tajimi et al., 2005	Japan	Municipal or Industrial Waste	Not Reported	PCDD/F and cPCB levels in breast milk of pregnant women.	No significant correlation between mean TEQ levels and distance from the incinerator. With respect to some individual congeners, negative correlation observed between concentration and distance of residence.	Not Reported
Non-MWI Facilities						
Llobet et al., 1998; Schuhmacher et al., 1999a; Schuhmacher et al., 2004a; Schuhmacher et al., 2004b; Nadal et al., 2005a; Bocio et al., 2005b; Schuhmacher et al., 2007;	Tarragona, Spain	Hazardous Waste	1999	Metals in Hair of Children; PCDD/Fs and PCBs in Breast Milk of Pregnant Women; Metals in Autopsy Tissues; PCDD/Fs and PCBs in Adipose Tissues	Overall general reduction in chemical concentration levels in human media.	Catalonian Government
Park et al., 2004; Leem et al., 2006	Korea	Industrial Waste	1998-2001	PCDD/Fs in blood serum of adults.	No statistically significant difference in I-TEQ between study and control groups.	Korean Ministry of the Environment
Kurttio et al., 1998	Finland	Hazardous Waste	Mid-to-Late 1980's	Mercury levels in hair of adults.	Increase in mercury exposure among workers and among those who lived near the plant. Increases were small and reflect exposure levels that do not produce adverse health effects.	National Public Health Institute
Evans et al., 2000	Timea Beach, Missouri, USA	Hazardous Waste Incinerator	1996-1997	PCDD/Fs in blood serum of adults.	Statistically significant decrease in 2,3,7,8-TCDD and TEQ in both the study and control groups over the length of the study. No significant differences between levels in study and control groups.	Missouri Department of Health; ATSDR

3.2.4 Other Articles Deemed Relevant to the Review

Four articles were identified which did not outline the methods and results of a specific environmental surveillance program, but which did contribute valuable information to the review.

Coutinho et al., 1998; Borrego et al., 2002 – Monitoring at Municipal Waste Incinerators in Portugal

Countinho et al. (1998) and Borrego et al. (2002) of the Institute for Environment and Development (IDAD), discuss the environmental impact assessment process facing municipal waste incinerators in Portugal as well as the subsequent surveillance programs that the facilities have undertaken. IDAD participated in the environmental impact assessment of both the Lisbon and Oporto municipal waste incinerators, either as coordinator or as the responsible party for the air quality component of the monitoring program.

Specifically, Borrego et al. discuss air quality management issues in Portugal, and use environmental surveillance at the LIPOR II municipal waste incineration plant in Oporto City as a case study example. The surveillance plan was developed by IDAD, and includes three components: environmental monitoring, public health monitoring and psychosocial monitoring. Twenty-six (26) monitoring stations were established within a radius of approximately 10 km from the incinerator. Baseline data was collected from 1998 to mid-1999, prior to the start of operations of the facility. Trial burns were then conducted during the second half of 1999, and the incinerator began operating in 2000.

The environmental monitoring plan included air quality, surface water, groundwater, agricultural biomonitoring and noise. Five of the 26 monitoring stations were dedicated to air quality. Monitored parameters include NO_x, CO, O_3, SO_2, PM_{10}, metals, and PCDD/F. Two of the monitoring stations are integrated into a government air quality monitoring network. Average PCDD/F concentrations in air were found to increase after with start-up of the incinerator, but the difference was not statistically significant. Average PCDD/F levels measured in the summer were found to be significantly lower than those measured in the winter. The authors note that the incinerator began operations in the winter months and that the majority of the samples were taken at this time. Over the course of facility operation, a decrease in average PCDD/F levels was observed, but this difference was again not statistically significant. Congener profiles were examined, and no significant difference was observed between the patterns in the baseline, start-up and operational phases.

> ***Relevance to Current Study***
>
> This study shows that although PCDD/F concentrations were measurable in air after start-up of the MWI facility, the levels were not statistically significant.

Rodrigues et al., 2003 – Valorsul Integrated Waste Management, Portugal

Rodrigues et al. (2003) who are representatives of Valorsul, the joint venture responsible for the operation of the municipal waste incinerator in Lisbon, Portugal, published a paper describing the facility and its operations. As previously mentioned in Section 3.4.2.1, Valorsul S.A. is a public joint venture representing five municipalities in Lisbon Metropolitan Area (North). Lisbon is the capital of Portugal, and a densely populated area. While it occupies less than 1% of the country in terms of space, it generates approximately 1/6 of the waste produced in Portugal. To cope with this issue, a waste management plan was created including a municipal waste-to-energy incineration plant, a landfill, a bottom ash processing and recovery plant, an organic transformation plant and a sorting plant and drop-off centre. All five elements were commenced operations between 1998 and 2003. The incineration plant is one of only two in the area of Lisbon and Oporto.

Relevance to Current Study

This review article documents the government mandated aspects of the environmental surveillance program required in Portugal.

As a component of the plant's operation, a government approved environmental surveillance program was established. Individual components of the program monitor air quality, water and sediment quality, terrestrial and estuarine ecosystems, accumulation of trace elements in soil, vegetation, water and sediments, environmental noise, public health and neighborhood attitude. With the exception of continuous air quality monitoring, which is conducted by Valorsul, all other components of the monitoring program are contracted out to independent entities specialized in the specific field of monitoring. As of the date of publishing, results of the programs have shown no significant impact due to the facility or data is still being collected to assess the impact.

Reis et al., 2008 – Ethics in Human Biomonitoring

Reis et al., 2008, as previously discussed in Section 3..2.3.1, oversee a human biomonitoring program surrounding two incineration facilities in Portugal. They have identified a number of relevant ethical issues associated with human biomonitoring programs. The authors cite transparency as the fundamental ethical issue in these programs. All participants have a right to be fully informed of the purpose of the study and have a right to decide whether or not they wish to participate. These rights form the basis of the informed consent that should be required from all participants to a human biomonitoring program. Groups with diminished autonomy, such as children, should have that responsibility shifted to their guardians and to the researchers. Children should be required to give affirmative assent to any study participation.

Another ethical issue that often arises is beneficence, as direct health benefits are not commonly the result of biomonitoring studies. Rather, health benefits are usually delayed and indirect. Biomonitoring also relies on sometimes invasive sampling techniques, such as the acquisition of blood samples. The above considerations rarely constitute an incentive to participate in such a study, which can make participant recruitment difficult. Payment for participation is generally discouraged by ethicists, although compensation for time and travel is acceptable. The authors note that recruitment of children has presented the most difficult challenge, particularly with regard to sampling of blood, while hair sampling can be significantly easier if combined with a hair-cut. The authors promote the merits of involving local health-care facilities, as they are in direct contact with the pool of potential participants, and a professional relationship of trust is already established.

Relevance to Current Study

This review article documents the ethical considerations for conducting human biomonitoring programs.

Conflict of interest is a significant ethical issue. Anytime a party has a vested interest in the results of the study, transparency becomes an absolute key issue. This applies particularly to facilities that finance surveillance programs to monitor their own impacts. Full disclosure of all methods, findings and results is essential to assuring the quality and confidence that can be put in the program. The identity of all participants should be protected and an established information and data practices protocol should be implemented. Finally, any human biomonitoring program should be reviewed and approved by an ethics committee to ensure that any ethical dilemmas are stated and solved before implementation.

Keune et al., 2008 – Human Biomonitoring and Risk Communication in Belgium

The Flemish Government (Dutch speaking region of Belgium) funded the Centre of Expertise for Environment and Health to investigate and monitor environmental health in Flanders. To do this a human biomonitoring campaign was started in 2001. Keune et al. (2008) discusses risk communication in the context of this program. Environmental and health problems are looked at differently depending on differences in personal background. Differences in risk perception are based on the ability of the individual to identify the problem. All forms of knowledge (science, intuition, experience, values) are relevant and should be taken seriously. As a consequence of the complex character of environmental and health research, scientific controversies and uncertainties are inevitable. Studies should be transparent in relation to choices made during the process of design of the study, research, interpretation, procedures, policy options, among other things. Participants in the study should be informed first about research results, before the press and the general public. Note that this concerns results on a general level, individual results being provided only to the participant, with an opportunity for resolution of individual issues of interpretation.

In Belgium, at the outset, the Center of Expertise for Environment and Health communicated information meetings before the beginning of the research in order to introduce the aims and means of the research. A website was set up, and press conferences and information meetings were held. With regards to the individual results participants were given the options of receiving the individual results at home, having the results sent to their doctor or receiving no results at all. Reference values were needed for participants to understand the results and compare them to "normal" values. A digital newsletter was also developed to publish research results and invite outsiders to give their opinions about the research.

Relevance to Current Study

This review article highlights risk communication aspects that should be considered in human biomonitoring programs.

4.0 GREY LITERATURE REVIEW

4.1 Objectives of the Grey Literature Review

While the scientific literature review brought forth considerable information, most of which originates in the academic community, it was anticipated that a full and complete review of the topic would necessitate a review of the grey literature – that is, literature not produced by bodies whose sole objective is publishing or that is not indexed in a scientific database. This may have included technical reports, government publications, regulations and legislation, conference proceedings, presentations, or unfinished "working reports".

Included in this section is information that was retrieved on national human biomonitoring programs that were not specific to an EFI or MWI facility. Information obtained from the grey literature review on government regulations of municipal waste incinerators is provided in Section 6.

4.1.1 Procedure for Conducting the Grey Literature Review

A two-pronged approach was taken to conduct the grey literature search.

- First - throughout the external contact review (described in Section 5.0), individuals were asked for leads to any published information available that would not have come up in a scientific literature search.
- Second - an internet-based grey literature search was conducted to locate and identify relevant works that pertained to environmental surveillance of incinerator facilities. Combinations of relevant keywords from the systematic review of the scientific literature were searched on two common search engines, Google™ and Yahoo!®.

The criteria for relevance of documents were identical to those outlined for the scientific literature review – English language, published after the year 1990, clearly defined study population exposed to incineration chemicals, and a clearly defined and relevant outcome of interest. Initially, the search identified 51 documents that were possibly relevant to the review of environmental surveillance programs. Once exclusion criteria and quality assessment (based on researcher judgment using the framework established in the scientific literature review but adapted to fit the scope of the grey literature article) was applied, 35 documents were excluded and 16 remained to be included for data abstraction. Seven were on environmental monitoring, five on human biomonitoring related to an incineration facility and four on national biomonitoring programs not related to an incineration facility.

4.1.2 Data Abstraction and Analysis of the Grey Literature

The documents were abstracted into a standard form outlining the following key article characteristics:

- Author/Organization, Title, Date of Publication, Location (if specified), Facility (if specified), Type of Monitoring; and,
- Summary of Environmental Monitoring or Human Biomonitoring Activities

In the summary section, the key points of the article were abstracted into a form suitable for later review. The form of this abstract is highly variable as the grey literature does not conform to any standard publication format. While some technical reports bore similarities to scientific papers identified in the scientific literature search, other documents such as presentations were more difficult to abstract. A summary of all data abstracted from the grey literature is available in Appendix D.

As with the scientific literature search, the grey literature was divided into two groups, based on whether the focus was environmental or human health monitoring. The following section outlines the recovered grey literature, and provides a summary of the information obtained.

4.2 Results and Findings of the Grey Literature Search

4.2.1 Grey Literature on Environmental Monitoring

Seven documents had information that directly pertained to environmental monitoring programs. Of these five documents described programs that were in the vicinity of a waste incineration facility. The most common environmental sample was ambient air followed by soil and vegetation and finally fauna. The chemicals of concern that were frequently studied were PCDD/F concentrations, PCBs, and metals.

The following are summaries of the environmental monitoring programs found in the grey literature search.

4.2.1.1 Grey Literature on Environmental Monitoring of Municipal Waste Incinerators

Monitoring Incinerator Emissions during Times of Relapse, Italy (Cenci et al., 2007)

The study's focus was to monitor a modern MWI facility at times when the chemical emissions may be the highest (i.e. a relapse). The researchers used moss samples to assess the potential impact of chemical emissions of trace metals (As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn). In addition, soil samples were used to assess the potential impact of PCDD/F emissions in the vicinity of the facility. Sampling was carried out in 2002 and 2005 in an area of 65km^2 around the municipal waste incinerator. The monitoring program concluded that the research campaigns did not show any increase in metal or PCDD/F concentrations in soils and vegetation that could be attributed to the MWI. The measured values were of a similar order of magnitude to the concentrations measured at agricultural sites and were lower than those measured in some urban and industrial areas. The authors concluded that the impact of the incinerator plant at Parona was small but long-term studies are considered essential to monitor the impact on the environment of fall-out in the study area.

Relevance to Current Study

This study confirms the results of the scientific literature review that a modern MWI facility has not impacted soil or vegetation in its local vicinity.

Energy-from-Waste Factsheet (Greater Vancouver Regional District, 2007)

The Lower Fraser Valley Air Quality Monitoring Network continuously monitors the ambient air environment at 30 sites throughout the Lower Mainland. No measurable impact has ever been associated with the Energy-From-Waste facility in Burnaby, BC. Further details are provided in the external contact portion of this study (Section 5).

4.2.1.2 Grey Literature on Environmental Monitoring of Non-Municipal Waste Incinerators

Swan Hills Special Waste Treatment Center (Alberta Health and Wellness, 2004)

Following a furnace malfunction in 1997 at the Swan Hills Special Waste Treatment Center (SHWTC), a facility that incinerates hazardous wastes from industrial and chemical applications, Alberta Health and Wellness launched a human health risk assessment to determine if potential releases of PCDD/Fs and PCBs might pose a risk to the surrounding environment. Starting in 1998, an environmental surveillance program was launched including, wildlife and fish tissue monitoring, and background contaminant monitoring.

Samples of deer and moose were harvested 10km, 20km, and 30km from the hazardous waste incinerator. In addition to this frozen moose and deer samples were collected from freezers of volunteer residents within a 30 kilometer radius from the facility. Road kill from areas greater than 30 kilometers from the facility were used as control samples. Liver, adipose (fat) and muscle tissues were analyzed for concentrations of PCBs and PCDD/Fs. Although total PCB concentrations in liver and muscle tissue were lower in 2001 and 1999 as compared to measured levels in 1997, their total PCB toxic equivalency (TEQ) increased in the both tissues in 2001, as compared to the 1997 and 1999 levels.

Relevance to Current Study

This study, although an environmental monitoring program, is not particularly relevant to the current study for MWI facilities. However, it does provide some indication of the type of studies that could be initiated in the event of a serious malfunction of a facility.

In addition to the meat samples above, brook trout (fish) were also sampled in 2 lakes within 20 km from the waste incinerator. A lake outside the vicinity of the facility was used as a control. Liver, muscle and scales tissues were used to determine PCDD/F, PCB and methyl mercury concentrations. The mean concentrations of total PCDD/Fs, total PCBs and their TEQ in the muscle and liver samples in brook trout from Chrystina Lake in 2000 were significantly lower than those collected in 1997. Also, the average concentration of total mercury in brook trout from Chrystina Lake was less than 200 µg/kg in 1999 and 2001.

Monitoring of a Chemical Waste Treatment Plant – Hong Kong (Environmental Protection Department of Hong Kong, 2002)

The document describes the ambient air monitoring program for a chemical waste treatment centre (CWTC) in Hong Kong. Ambient air is monitored from 2 locations. The first is from the rooftop of the CWTC as well as at an estate within the depositional range of the facility. Sampling for particulates, SO2, NO2, VOCs, and PCBs are conducted every 6 months. For PCDDs sampling is carried out once a month. Monitoring results from two years showed that the average dioxin levels in the ambient air close to the CWTC were in the range of 0.053-0.069 pg I-TEQ/m^3, which was within the normal range found in other parts of Hong Kong.

Relevance to Current Study

This study confirms the results of the scientific literature review that a hazardous waste incineration facility with modern pollution control technology may not impact local air quality.

Environmental Monitoring at a United States Naval Air Facility Adjacent to the Shinkampo Industrial and Medical Waste Incineration Complex in Atsugi, Japan

Two papers were published in the scientific journal *Organohalogen Compounds* which were retrieved through the grey literature and external contact process (Lorber et al., 2002; Walker et al., 2002). The papers describe air and soil monitoring at a United States Naval Air Facility adjacent to the Shinkampo industrial and medical waste incineration complex in Atsugi, Japan. The incinerator was in operation until May of 2001 at the time of sample collection. Through the spring and summer, the prevailing winds were such that stack emissions were predominately in the direction of the naval base. The US Navy was not permitted to stack-test emissions, nor were they able to obtain stack emissions data from the facility. As a result, an air and soil monitoring program for PCDD/Fs was established at the base that led to a human health risk assessment.

Surface soil samples were taken at 73 locations, with the collection of subsurface samples at a subset of 25 locations. Sampling occurred in both areas of concern and reference areas. As expected surface soil samples had a higher PCDD/F TEQ concentration than those collected at depth. A clear distinction was observed between PCDD/F TEQ levels at sites within 500 m downwind of the incinerator. PCDD/F congener profiles were similar in all samples, except one anomalous sample, and also were similar to a soil sample collected near a municipal waste incinerator in Columbus, Ohio. The authors concluded that the PCDD/F impacts were within the surficial samples and they did not mobilize deeper into the soil column. The authors also investigated indoor dust samples and concluded that only light, fine soil particles or airborne particulate matter were transferred indoors.

Relevance to Current Study

Although not of particular relevance to a MWI facility, it is another study that was initiated on the basis of concern of the residents (of the Naval Base).

It should be noted that the Study Team did not find the comparisons of the Japanese levels of PCDD/F to a facility in the USA particularly relevant.

Five outdoor and seven indoor air quality stations were established throughout the naval facility. Three hundred and forty-four outdoor and 67 indoor samples were collected on six days, spread out over several months. The average PCDD/F TEQ was reported as 1.57 pg/m^3 on the naval base, which is higher than the average urban (0.12 pg/m^3) and rural (0.017 pg/m^3) PCDD/F concentrations in the United States. However, these values may not be relevant for comparison in Japan and no local control or monitoring station was established. The highest concentrations of PCDD/F were observed in a maintenance building directly downwind of the facility. Congener profile analysis showed strong similarities (or concordance) between the Atsugi Naval Base to those in Columbus, Ohio at a municipal waste incinerator.

Guidance Manual for Public Health Assessors (Willis et al., 2002)

The ATSDR document outlines recommendations that should be followed in the event an ambient air monitoring program is to be initiated to study air emissions from a hazardous waste incinerator in the United States. The ATSDR states that hazardous waste incineration sites should employ ambient air monitors or stack data if a human health risk assessment indicates the potential for air releases of contaminants at concentrations that could cause adverse health effects.

The guidance manual suggests that ambient air monitors should be located at the fence line of the facility, or where the air dispersion modelling indicated that people could be exposed to harmful levels of chemicals. They indicated that the fence-line monitoring stations should be placed in the predominant wind direction(s), near where fugitive emissions are likely to be generated or detected. One to four chemicals should be chosen as indicators of exposure to site contaminants. The criteria for the selection of these compounds should include:

1) the methods available (i.e. chemicals that can be quickly and easily identifiable),

2) available in detectable concentrations,

3) unique to incineration,

4) representative (of the various classes of chemicals present),

5) toxicity (present on-site in concentrations that could cause adverse health effects).

Relevance to Current Study

Although developed for hazardous waste incineration facilities, it is useful to note that they suggest that such a monitoring program be established in the event that a human health risk assessment concludes that there may be a concentration of a chemical that could pose risk to human health.

The guidance manual also stresses the importance of a baseline sampling program prior to the facility start-up.

4.2.1.3 Environmental Monitoring Programs Not Initiated by Incineration Facilities but may be of Relevance

The final two documents are examples of monitoring programs that were not initiated by the presence of a waste incinerator (Commissioning Organization of the UK Environmental Agency, 2003; Wood Buffalo Environmental Association, 2007). Although not related to incineration, they provide useful information on the triggers and methodology of environmental monitoring programs.

In a general sense, an environmental monitoring program may be required if there are vulnerable receptors and if the emissions will be a significant contributor to an environmental quality standard that may be at risk. They are also useful to validate modelling work. When implementing a monitoring program the need must be considered for land contamination, health impacts, groundwater, surface water, and noise. In addition, when creating a program the following should be considered:

- chemical to be monitored, standard reference methods, and sampling protocols;
- monitoring strategy selection of monitoring points, optimization of monitoring approach;
- determination of background levels contributed by other sources;
- uncertainty for the employed methodologies and the resultant overall uncertainty of measurement;
- quality assurance and quality control procedures, equipment calibration and maintenance, sample storage and chain of custody;
- reporting procedures, data storage, interpretation of results, reporting format and provision of information for government body.

Relevance to Current Study

These general guidance documents on establishing environmental monitoring programs stress that they should be initiated if emissions are believed to be a significant contributor that could alter or impair environmental conditions.

No evidence that a modern MWI facility would impair its surrounding environment was uncovered in the scientific literature review.

4.2.2 Grey Literature on Human Biomonitoring

Five grey literature articles that reported on the results of human biomonitoring surrounding incineration facilities were included in this study. Age groups studied ranged from newborns to the elderly (up to age 65). Sample tissues collected included urine, blood, serum and hair. In the studies that assessed newborns and expectant mothers, breast milk and umbilical cord blood were collected. Chemicals varied by study, but included PCDD/F, metals, PAHs, and PCBs.

4.2.2.1 Grey Literature on Human Biomonitoring of Municipal Waste Incinerators

Flemish Human Biomonitoring Program (Schoeters, 2007a; Schoeters, 2007b)

The most comprehensive human biomonitoring program pertaining directly to waste incineration was the Flemish Human Biomonitoring Program, initiated by VITO of Belgium. The goal of the program was to identify baseline values or reference values for environmental pollutants in the Flemish population. Among the populations included in the program were populations living in the vicinity of incineration facilities. The environmental pollutants of concern were persistent organic chlorinated compounds, metals, and metabolites of PAHs and benzene. Through the collection of umbilical cord blood, blood, and urine, questionnaires and medical files the researchers were able to arrive at a number of preliminary conclusions. They have determined that area of residence is related to exposure of these chemicals, although no particular alarming trends were reported. In addition, factors such as age, gender, smoking and nutritional intake were important determinants of chemical exposure. These studies were further reported by Schoijen et al. (2008) in Section 3.2.3.1, where they reported no statistical correlation of chemical body burden and proximity of residence to a MWI.

> ***Relevance to Current Study***
>
> This study confirms the results of the scientific literature review that residence proximity to a MWI facility did not result in any alarming trends in chemical data analysis.

Environmental Health Surveillance Program (ProVEpAs) – Portugal (Reis, 2007)

The main goal of the ProVEpAs program is to monitor magnitude, spatial, and temporal trends of solid waste incinerators. The program was initiated with the aim of guaranteeing quality of environmental medium in the incinerator's area of influence; as well as, to ensure the safeguarding of public health for people living in the same area. To satisfy these objectives two waste incinerators in Portugal were chosen as study areas (Valorsul and Meia Serra). Within the defined study areas the researchers recruited members of the general population which included mother-child pairs, breast feeding women and children less than 6 years. Chemical concentrations monitored included PCDDs and heavy metals. The biological materials to determine the chemical concentrations were blood, public hair, umbilical cord blood, breast milk and scalp hair. Preliminary results of the Valorsul and Meia Serra monitoring programs suggest differences between exposed and control groups were not statistically significant for exposures or for pathologies and health conditions. Results suggest the effectiveness of source control measures in relation to both in

> ***Relevance to Current Study***
>
> This study confirms the results of the scientific literature reported by Dr. Reis and her colleagues, where no statistical correlation has been found between MWI chemical emissions and in tissues of residents living in their vicinity.

incinerators under study. Further information on these studies was obtained in the Scientific Literature Review (see Human Biomonitoring Studies by Dr. M. Fatima Reis, Section 3.2.3.1).

French PCDD/F Serum Levels for Residents in Close Proximity to Incinerators (Frery et al., 2008)

This document discussed the PCDD/F burden of populations surrounding numerous waste incinerators, of varying age and technology, in France. Study participants were recruited using random methods. The criteria for involvement included being a resident of the area for at least 10 years, no occupational exposure to PCDD/F and have not breastfed (or very briefly) in the last 15 years. The researchers conducted face-to-face interviews where subjects answered a questionnaire about their individual characteristics, food habits and domestic environment. Blood samples for serum were taken to assess dioxin and PCB body burden. The study results showed that living near an incinerator had no significant effect on serum dioxin levels, except for consumers of local animals products (including dairy products and eggs), especially for those who lived near old incinerators that have polluted in the past. This observation was more marked among farmers. Personal factors and food consumption, in particular fish products, were found to be critical determinants of PCDD/F serum levels.

Relevance to Current Study

As found in the scientific literature, PCDD/F serum concentrations were only elevated in consumers of local animal products surrounding older facilities.

No correlation in PCDD/F serum levels were found for residents living in close proximity to modern MWI facilities.

4.2.2.2 Grey Literature on Human Biomonitoring of Non-Municipal Waste Incinerators

Swan Hills Special Waste Treatment Center (Alberta Health and Wellness, 2004)

This is an extension of the study previously discussed in the grey literature for environmental monitoring of the Swan Hills Special Waste Treatment Center (SHWTC), following a furnace malfunction in 1997. In addition to the environmental monitoring program, Alberta Health and Wellness launched a human health risk assessment to determine if potential releases of PCDD/Fs and PCBs might pose a risk to the local residents.

Relevance to Current Study

This study, although a human biomonitoring program, is not particularly relevant to the current study for MWI facilities. However, it does provide some indication of the type of studies that could be initiated in the event of a serious malfunction of a facility.

Starting in 1998, an environmental surveillance program was launched including human blood monitoring, wildlife and fish tissue monitoring, and background contaminant monitoring. The area under study included the Town of Swan Hills and all communities within a 100 kilometer radius of the hazardous waste facility. To be eligible for the study, participants needed to be over 18 years of age, a resident in the Swan Hills area, and have participated in the 1997 Swan Hills Health Assessment Survey. To determine the levels of PCBs and PCDD/Fs participants were asked to participate in a telephone survey and subsequently have their blood taken at local hospitals. Thirty-eight of the 146 initially contacted residents participated in the human blood monitoring program. The study concluded that concentrations of total PCBs and PCDD/Fs in blood were similar in residents living in the Swan Hills area in both the

1997 and 2001 surveys. However, exposure ratios for some individuals consuming wild game and fish would be greater than Health Canada recommended levels and that a long-term program be continued.

4.2.2.3 Human Biomonitoring Programs Not Initiated by Incineration

The remaining three (3) documents outline general guidelines for the effective implementation of a human biomonitoring program (Commission of the European Communities, 2004; Den Hond, 2006; Expert Team to Support Biomonitoring in Europe (ESBIO), 2007). A human biomonitoring program should collect biological samples in the most minimally invasive method possible. The least invasive sample is hair, followed by urine and breast milk and finally blood/serum samples. Ethical concerns must be addressed before any sampling program is to be initiated. Ethical issues include autonomy, sampling procedure and consent forms (most importantly for children), and dissemination of results. The use of questionnaires is also recommended. This would help researchers control for confounding variables that may bias the results of the human biomonitoring study. In summary, a human biomonitoring program has to be conducted in a coherent and harmonized approach by means of commonly developed protocols, strategies, and tools ensuring reliable and comparable data.

Relevance to Current Study

These documents clearly outline a number of issues that would need to be taken under advisement in the development of any human biomonitoring program.

They stress that these programs should not be entered into lightly given the ethical issues involved in such programs.

4.2.3 Summary of Findings of the Grey Literature Review

The results of the grey literature review were consistent with the findings of the systematic review of the scientific published literature. The fact that both the findings of the published and unpublished literature were similar is an encouraging result. The Study Team believes that it is unlikely that additional information may have been missed during this review, which would alter our findings or conclusions.

4.2.4 **National Human Biomonitoring Programs**

Throughout the grey literature and external contact review, it was observed by the review team that many countries have implemented a national human biomonitoring program aimed at understanding chemical concentrations in the general human population. This is not particularly associated with any one industry, but rather to examine the overall population level of exposure to environmental contaminants. The following section provides a brief overview of some of these programs, and their applicability to potential incineration monitoring programs.

4.2.4.1 Canadian Health Measures Survey (CHMS)

The Canadian Health Measures Survey (CHMS) was launched in 2007 by Statistics Canada and Health Canada in order to establish a baseline of health data representative of the general Canadian population. In Cycle 1 of the CHMS, which is currently ongoing, 15 communities, each with a population of at least 10,000 people, were selected from across Canada for participation. Individuals aged 6 to 79, are eligible for selection in the CHMS, and the program is designed to represent 97% of the Canadian population. A total of 5000 participants have been deemed necessary to achieve the goals of the CHMS, and as a result, 350 participants from each location were selected.

Participants are first interviewed in their home, and later must visit a mobile clinic where physical measurements are taken; including but not limited to, physical measures (such as lung function, physical activity and cardiovascular fitness), and blood and urine measures (such as nutritional status and environmental exposure). Environmental exposure would include exposure to pollutants such as lead, mercury, other metals and organic compounds.

All biological tissue samples are stored for future analyses and the entire program has undergone ethical review. Among the sites included in Cycle 1 is Clarington, Ontario, which is the currently anticipated location of the proposed EFW facility. The reviewers have confirmed with CHMS that results will not be available by region, but rather solely on a national basis as that is the primary purpose of the survey at this stage. Cycle 2 of the CHMS has been confirmed to be similar in structure to Cycle 1, although it is unknown at this stage whether or not Clarington will be included as a site. Once again, as with Cycle 1, the results will only be available on a national basis. Planning for Cycle 3 has not yet been initiated. (Personal communication, Ellen Lee, December 9, 2008). More information on the CHMS is available in Appendix F-1.

4.2.4.2 Maternal-Infant Research on Environmental Chemicals (MIREC)

The Maternal-Infant Research on Environmental Chemicals (MIREC) study will be running from 2007 to 2012 and is funded by Health Canada, the Ontario Ministry for the Environment and the Canadian Institutes for Health Research. MIREC is a national study of 2000 female participants from 10 major metropolitan areas of Canada (including Toronto). Women in the first trimester of pregnancy are recruited and followed through term into approximately 8 weeks after pregnancy. Along with questionnaires, mothers are expected to provide samples of blood, hair, urine, breast milk, umbilical cord blood, and meconium (baby's first stool). The study will determine levels of metals such as lead, mercury, arsenic, magnesium and cadmium as well as organic chemicals such as PCBs, PBDEs and phthalates. The study is intended to complement the CHMS, which does not include pregnant women and infants among its study population. This study will prove to be a valuable tool against which to benchmark future environmental contaminant levels in industrial exposed populations. More information on MIREC is available in Appendix F-2.

4.2.4.3 National Health and Nutrition Examination Survey (NHANES)

Similar in nature to the CHMS in Canada, the United States has been conducting various incarnations of the National Health and Nutrition Examination Survey (NHANES) since the 1960's. Originally, three National Health Examination Surveys (NHES) were conducted, focusing on chronic disease in adults and the growth and development of children (NHANES, 2008). As the desire grew to link nutrition with its effect on health, the first NHANES survey began in 1971. Three NHANES surveys as well as a Hispanic HANES survey were completed between 1971 and 1994.

In 1999, a continuous NHANES survey began and continues to be operated. Each of the individual NHANES survey incorporated between 16,000 and 40,000 people, of all ages and backgrounds. Certain tests done with respect to a specific population group in one survey were repeated in further surveys in order to assess temporal trends. The current continuous NHANES survey tests approximately 7,000 people each year for a large number of parameters, including monitoring of environmental exposure to chemicals. The NHANES results have affected public policy and opinion in the U.S., examples of which include the phasing out of leaded gasoline, and the establishment of a link between high levels of cholesterol and heart disease. More information on NHANES is available in Appendix F-3.

4.2.4.4 Human Biomonitoring Activities in the European Union

In 1977, the Commission of the European Communities (CEC) enacted the "council directive on biological screening of the general population for lead" requiring members to apply a common procedure for assessing exposure of populations for lead (Angerer, 2007). This, along with a directive for control of lead exposure in the workplace, was the only human biomonitoring activity of the CEC over a 25 year span. In 2003, the EU adopted the European Environment and Health Strategy, which led in 2004 to the Environment and Health Action Plan 2004-2010. Action 3 of the Action Plan sought to "develop a coherent approach to biomonitoring in Europe" (CEC, 2004).

In order to implement Action 3, an implementation group on human biomonitoring was formed, comprised of 30 members from the European Union (EU) member states, as well as Croatia. Each implementation group member must report back to a government representative responsible for human biomonitoring in their member state. The timelines proposed that a protocol for biomonitoring be in place by the end of 2006, with a biomonitoring pilot project starting immediately afterwards, running until 2010. This pilot project would attempt to test the proposed protocol through practical applications, employing the "learning by doing" concept (ESBIO, 2007).

In 2005, funded by the European Commission under the 6th Framework Programme for Research and Technological Development, the Expert Team to Support Biomonitoring in Europe (ESBIO) began work on the EU protocol for human biomonitoring, and released its final report at the end of 2007 (ESBIO, 2007). The ESBIO team was comprised of 22 people from 17 member states and Croatia – all of whom were members of the Action 3 implementation group. As per the protocol, the European Inventory on Human Biomonitoring Activities was born, which attempts to catalog both the sum of the past and ongoing human biomonitoring activities in EU, as well as hold a Database of Published Articles on European Human Biomonitoring Activities (DPA/EHBA).

With a common protocol for HBM in place, the 7th Framework Programme for Research and Technological Development will provide funding for the human biomonitoring pilot project, denoted as the European Network on Human Biomonitoring (European Commission, 2007). This program is currently ongoing as current researchers attempt to use the proposed protocol for HBM with the goal of providing feedback on improvements for a common human biomonitoring program in the EU. The ultimate goal of the current human biomonitoring activities in the EU will be to launch a full-scale human biomonitoring program in which all EU member states carry out HBM activities in a common, unified manner.

5.0 EXTERNAL CONTACT INTERVIEWS

5.1 Objectives of the External Contact Interviews

Many governmental or legislated environmental surveillance programs are not published in the scientific literature, relying instead on internal or external governmental websites and documents with limited dissemination. In order to obtain a more holistic view of the practices of environmental surveillance programs associated with the energy-from-waste industry, it was essential to contact individuals in this field of work, who are directly involved with these programs.

Although many valuable contacts were made, and interviews conducted during this phase of the project, unfortunately not all of those who were contacted by the reviewers responded to our repeated inquiries. However, the reviewers believe that the information gained from respondents was sufficient to support the study findings and conclusions.

5.2 External Contact Procedure

Figure 5-1 outlines the protocol that was used for contacting and obtaining relevant information from external sources. Once an individual subject matter expert was identified, a standard email describing the project was sent to this person (Appendix B). The email requested a phone interview with the individual based on questions provided in a questionnaire to be sent prior to the phone call. If no reply was received within 7 days of the initial email, a standard follow-up email was sent reminding the individual of the project and the desire to obtain information. If no reply to the follow-up email was received, an attempt was made to contact the individual by telephone. If this failed, the reviewer moved on to other individuals identified for contact.

Once email contact was made, and the individual agreed to move forward in the process, a standard email was sent to the individual containing the questionnaire. In some cases, the contact preferred to answer the questionnaire in writing, while other contacts preferred the telephone interview method. The method of information collection requested by the individual was respected by the Study Team. Where the contact did not reply to the emails, but made themselves available during initial phone contact, with their permission, the interview was launched immediately without sending the questionnaire in advance.

The questionnaires were designed to obtain a maximum amount of information using a minimum number of questions. As with any survey, the response rate can generally be correlated to the level of effort required to complete the survey/questionnaire. Where phone interviews were conducted, the reviewer took notes throughout the conversation and immediately following the interview, prepared a summary email outlining the minutes of the interview for the approval of the individual.

Examples of the standard emails, as well as the questionnaires, can be found in Appendix B. Based on the occupation/interest of the contact, these emails or questionnaires were personalized or slightly modified to best appeal to the contact.

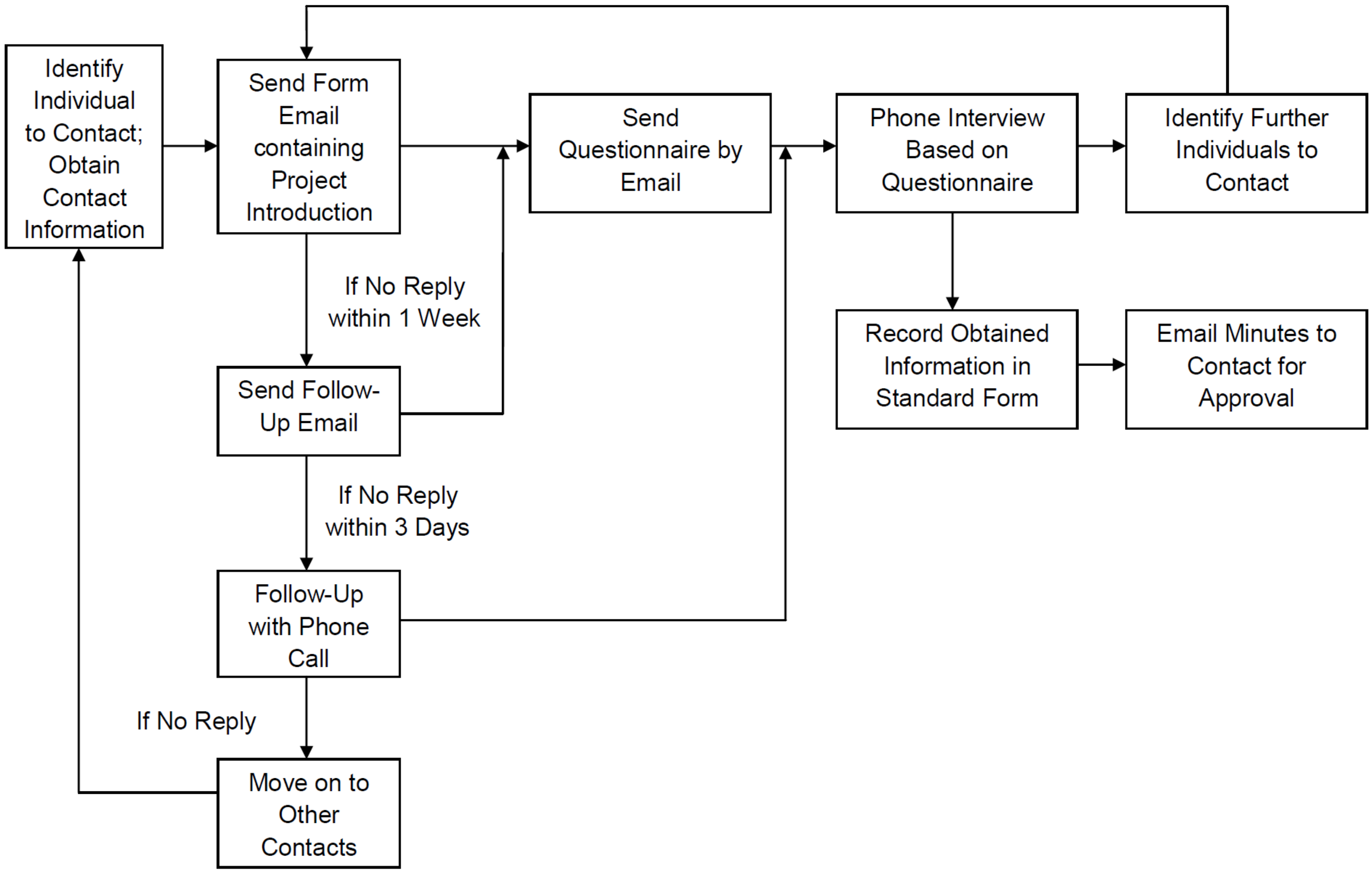

FIGURE 5-1 OVERVIEW OF EXTERNAL CONTACT PROCEDURE

5.3 Contact Selection

The selection of individuals to contact during this process proceeded in a two tiered format. Tier 1 consisted of all previously established contacts, including among them, the list of European EFW facilities visited by the Regions of York and Durham in 2007; as well as the list of academic and governmental members associated with the European Union Human Biomonitoring Implementation Group. With regards to this group, further research was done on these individuals to determine which of them had direct involvement in Energy-From-Waste based projects. In addition, contacts at the Ontario Ministry of the Environment (MOE), Health Canada Canadian Health Measures Survey, and environmental regulators in other Canadian jurisdictions were contacted.

Tier 2 contacts were those that were identified throughout the review process and consisted of supplemental contacts identified during the contact of Tier 1 individuals; as well as authors of articles found and deemed relevant in the scientific literature search.

5.4 Results and Information Obtained from External Contacts

5.4.1 External Contact of Incineration Facilities Owners/Operators

The first group of individuals approached was the contacts previously established at the incineration facilities visited by the Regions of York and Durham during their incinerator tour of Europe in July 2007. Emails were sent to 7 individuals at 5 facilities. As well, the group met with the German EFW Association and representatives from the Italian Agency for the Protection of the Environment. One contact from each of these two groups was included. An email was sent to the general facility address in this case, asking to be referred to an appropriate contact. From this first round of efforts, the reviewers received one reply, from Francesca Faraon, one of the two contacts at the Italian VESTA Incinerator. Her response was a referral to Gianni Teardo, the other contact at the facility; the reviewers could not get in contact with Mr. Teardo.

A second round of emails was sent out to the same individuals. One additional reply was received, from Giuseppi Sgorbati at Italian Agency for the Protection of the Environment. We were referred to Dr. Silvana Angius, also with the Agency, who accepted our questionnaire and invitation to speak on the phone. A summary of the interview with Dr. Angius is provided in Section 5.4.2.2

Following the contact protocol, we then attempted to obtain phone numbers and contact the remaining individuals. The reviewers spoke with and interviewed Mr. Carsten Spohn, Director of the German EFW Association (ITAD), and Mr. Jonas Eek, Manager of the Energy Department for the SYSAV Facility in Sweden. Other contacts could not be reached after multiple attempts.

A summary table of external contact efforts can be found in Appendix G.

5.4.1.1 Carsten Spohn, Managing Director, ITAD, Germany

Mr. Spohn (personal communication, December 1, 2008) indicated to the reviewer that EFW facilities in Germany conduct emissions monitoring, at the stack for typically expected airborne pollutants, but do not conduct any additional environmental surveillance programs (e.g., ambient air monitoring or human biomonitoring) to assess the impact of the facility to the neighboring areas. He did however indicate that there are more than 100 ambient air monitoring stations in Germany to collect data on the impact of industrial activities in general. All EFW plants in Germany are also wastewater free, in that any process wastewater is recycled back into the process.

EFW facilities are regulated by the National Ministry of the Environment, which has a special department dedicated to industrial emissions. Human biomonitoring is not conducted because emissions levels are too small to be detected and attributed to EFW facilities. The European Union is preparing a new industrial emissions directive, however this will not likely impact the state of affairs in Germany as current German stack emissions regulations are considerably stricter than the EU directive.

Relevance to Current Study

Germany conducts only stack monitoring of EFW facilities.

5.4.1.2 Jonas Eek, Energy Department Manager, SYSAV, Sweden

Mr. Eek (personal communication, December 1, 2008) indicated to the reviewer that EFW facilities in Sweden are regulated by the National Environmental Court, which must provide a permit to facilities in order for them to operate. This permit outlines the emission targets that the facility must meet, and is specific to the facility and its location and circumstances. When applying for the permit, an environmental impact assessment is completed, which includes modeling the impacts of the facility's emissions on the surrounding area, but no actual measurements are taken in this process.

Stack emissions are continuously monitored and an annual environmental report is a mandatory requirement of the facility permit. Mr. Eek indicated that to his knowledge there are no facilities that conduct environmental surveillance.

Relevance to Current Study

Sweden conducts only stack monitoring of EFW facilities.

To his knowledge, there are no anticipated changes in the way facilities will be regulated in Sweden in the near future. Facilities are bound to the EU directive and levels are frequently lower than these established guidelines.

5.4.2 Government

Seven (7) individuals were identified in Tier 1 based on their involvement as government contacts for the European Union (EU) Implementation Group of Human Biomonitoring. These 7 individuals were selected based on their location in countries that are known to have active incineration facilities. In particular, Portugal (2 contacts), Germany, Belgium and Denmark (2 contacts) were targeted, as well the EU representative. Representatives from Germany, Belgium and Denmark redirected the reviewer to more appropriate contacts who were contacted in Tier 2. No response was obtained from the Portuguese representatives. The EU representative was obtained on the telephone and briefly agreed to answer a few questions.

In Tier 2, the reviewers were told by contacts in Germany that they could not assist our review, or were unsuccessfully redirected. Tier 2 contacts from Belgium and Denmark could not be reached. A number of more local government contacts were also identified. The reviewers spoke with Ellen Lee of Health Canada, who is a toxicologist with the Canadian Health Measures Survey. The information obtained from Ms. Lee was discussed in Section 4.2.4.1. Andrew Neill, a Senior Waste Engineer with the

Environmental Assessment and Approvals Branch at the Ontario Ministry of the Environment provided the reviewers with the Certificates of Approval for incineration facilities in Ontario (discussed in Section 6). A number of individuals assisted with obtaining information on the energy-from-waste facility in Burnaby, BC. Finally the reviewers contacted Dr. Matthew Lorber, a researcher at the United States Environmental Protection Agency (US EPA). Dr. Lorber provided the reviewers with information on the environmental monitoring conducted by the United States at the naval base in Atsugi, Japan (discussed in Section 4.2.1.2).

A summary table of external contact efforts can be found in Appendix G.

5.4.2.1 Dr. Birgit Van Tongelen, European Union

Relevance to Current Study

The EU legislation mandates only stack testing at EFW facilities.

Dr. Van Tongelen (personal communication, November 26, 2008) stated that to her knowledge, the only legislated monitoring requirement for an incineration facility in the European Union is emissions monitoring at the stack according to the European Directive 2000/76/EC (further discussed in the Grey Literature Review – Section 4.4.2.3). To her knowledge, no human health or environmental monitoring programs are required throughout the European Union.

5.4.2.2 Dr. Silvana Angius, Lombardia Region, Italy

Dr. Angius (personal communication, December 11, 2008) is the Responsible Authority for the Air Pollution Unit at the Regional Agency for Environmental Protection for Lombardia. Lombardia is located in Northern Italy, and includes Milan as its major metropolitan area.

Relevance to Current Study

Italy follows stack testing requirements of the EU directive, but in many instances also requires ambient air monitoring surrounding an EFW facility.

Italy's governmental structure is similar to Canada's. There is a Central government with a Ministry of the Environment. Each region in Italy has its own Regional government, and in turn, there are Regional Ministries of the Environment. Most incinerators are regulated by the Regional Ministries of the Environment, with the exception of the very large (rated thermal input > 300 MWth) incinerators, which are governed at the Central level.

Italian air emission regulations for incineration facilities follow the European Directive 2000/76/EC, essentially word-for-word. All facilities must conduct an Environmental Impact Assessment and obtain an Integrated Pollution Prevention and Control authorization prior to construction. If during these investigations, it is deemed necessary, the approval for the facility may require emissions limits that are stricter than those set out in the European Directive.

Human biomonitoring is not typically done at incineration facilities in Italy; however, environmental monitoring (typically ambient air monitoring) is often required and mandated in the facility authorization. This monitoring typically starts before construction commences in order to establish a baseline. An example of this would be the facility in Milan which was required to conduct ambient air monitoring during the first 3-4 years of operation for dioxins and other pollutants in several areas.

Dr. Angius does not foresee any anticipated changes to the way incineration facilities are regulated in the near future. She believes that current environmental monitoring practices in Italy are adequate for the protection of the environment and human health as the impact of modern waste incinerators is very small. Italy does not have a national human biomonitoring program; however, individual human biomonitoring programs have occurred near major environmental accidents.

5.4.2.3 Chris Allan, Metro Vancouver, Canada

Mr. Allan (personal communication, January 9, 2009) is a Senior Engineer with Metro Vancouver and among his responsibilities he manages the contract that the EFW facility holds with Metro Vancouver. In the 1980's, the facility conducted an environmental baseline consisting of air, soil and vegetation samples. After facility operation commenced, this environmental monitoring program was continued for several years. The results of the program failed to identify any impact to the environment caused by the operation of the facility. After these results were obtained, the facility scaled back the monitoring program and limited it to ambient air monitoring. Originally, this consisted of a number of continuous air samplers surrounding the facility and a mobile air unit that was operated in a full circle around the facility. After further years of similar results in which no impact was observed as a result of the facility, the air monitoring program was progressively scaled back to 3 continuous samplers which have since been integrated into a regional air quality monitoring network, for the last 10-15 years. As a part of this network, these monitors are now operated by Metro Vancouver, but remain in positions that would be sensitive to emissions from the facility. No significant increase in pollutant levels has been found and attributed to the facility to date.

> ***Relevance to Current Study***
>
> In British Columbia during the initial years of MWI facility operation there was a requirement to conduct environmental monitoring. After years of not finding any change in environmental conditions the program was discontinued.

Human health studies have never been broached by the facility or Metro Vancouver as the results of the stack emissions and environmental monitoring programs have never justified the need for such a study. Currently, Mr. Allan states that with regard to public awareness and perception of the facility, there couldn't be a facility more under the radar in Metro Vancouver. The majority of citizens don't know that the facility exists. Among those who come to the facility to see its operations, the most common comment received is "Why aren't we doing more of this?". Mr. Allan acknowledges that there are those who are against the operation of the facility, and that this will likely always be the case, but that they are the minority.

5.4.2.4 Dr. Goran Krstic, Fraser Health Authority, Canada

> ***Relevance to Current Study***
>
> The Fraser Health Authority in British Columbia does not plan to implement an environmental or human monitoring program surrounding the local MWI facility.

Dr. Goran Krstic is a Human Health Risk Assessment Specialist with the Fraser Health Authority. Fraser Health Authority has not conducted any health studies or surveillance activities at or around the facility in the recent past and there are no current plans to do so (Personal Communication, Goran Krstic, January 8, 2009). General air quality in the valley is of greater concern than the impact of point sources. Examples of these concerns might include the:

- Impact of traffic which can overwhelm background levels and sources of pollutant

- Indoor air interventions because of the greater exposure time, and often higher concentrations of air contaminants, with a greater potential to reduce these exposures

There is a good deal of agricultural areas in the valley, leading to a large amount of ammonia in the air. This ammonia can interact with other air pollutants such as NO_x and SO_2 to produce ground level ozone which is a pollutant of concern.

5.4.3 Academia and Expert Contacts in the Field of Environmental Surveillance of MWI Facilities

Seven individuals were identified during the scientific literature review who the review team deemed to be experts in the field of environmental surveillance surrounding incineration facilities. Of these individuals, successful contact was made with four individuals, all active in the field of environmental surveillance. One of the individuals, Dr. Elena De Felip of Italy, referred us to another individual in her department, with whom we were not able to make successful contact. Dr. Nadine Fréry of France briefly explained the program she developed and sent the reviewers some written material further explaining her program. This information has been included and described in the Grey Literature Review (Section 4.2.2.1).

A summary table of external contact efforts can be found in Appendix G.

5.4.3.1 Dr. M. Fatima Reis, Institute of Preventative Medicine, University of Lisbon, Portugal

Dr. Reis (personal communication, December 17, 2008) has been involved in human health surveillance programs at a municipal waste incinerator near Lisbon for almost 9 years and at a municipal, clinical and slaughterhouse waste incinerator on Madeira Island for almost 6 years. Since 2007, she has also been involved in the surveillance program at the only Portuguese clinical waste incinerator, located in Lisbon.

Incineration facilities in Portugal are governed at the central (national) level of jurisdiction, according to national legislation (Decreto-Lei n.85/2005, April 28, 2005). Responsibility for the facilities is handled by the Environment and Health Ministries. Under this national legislation, facilities are required to conduct emissions monitoring in line with European Directive 2000/76/EC. All facilities are required to conduct Environmental Impact Assessment Studies (established by Decreto-Lei n.197/2005, November 8th 2005) prior to licensing of the facility. If the recommendations of the Environmental Impact Assessment Study demonstrate the need for environmental or human biomonitoring, then it can be implemented into the facility license, thus becoming a regulatory requirement of the facility.

Relevance to Current Study

Dr. Reis has reported that she believes that the human biomonitoring programs that she has carried out in Portugal have served to alleviate public concern surrounding living in close proximity to an incineration facility.

These environmental surveillance programs are then contracted out by the facility to independent institutions (such as Universities or recognized companies in the environment and health sectors) through a public tendering process. A Steering Committee is established which includes relevant stakeholders such as national and municipal government representatives, non-governmental organizations (NGOs) and representatives of the general public, all nominated by the regulatory entity. The facility must then provide all monitoring results and reports to the Steering Committee.

Dr. Reis' surveillance activities includes monitoring of human exposure to metals, PCDD/Fs and PCBs, using human biomonitoring strategies, as well as monitoring of associated adverse health effects using participant questionnaires and/or analysis of health registries. All relevant methodologies and results from the surveillance programs are published in the primary scientific literature. Her programs to date have provided useful results related to human exposure to the most critical pollutants potentially emitted by the incineration process (such as metals and dioxins) and have demonstrated statistically insignificant differences between potentially exposed populations as compared to control groups.

Costs that might arise from such programs include personnel costs for a permanent team comprising experts from several fields (chemistry, toxicology, epidemiology, statistics, sociology, medicine, environmental sciences); as well as laboratory and field technicians, analytical costs (clinical and chemical analysis), and field work costs (sample collection and questionnaire administration).

Dr. Reis cites the most significant difficulty encountered in carrying out such a program as being the collection of biological samples using invasive techniques, such as blood collection, in particular when the subjects are children. She states that in the first years after the incineration facilities were installed or updated, the public opinion of the facilities was certainly positively impacted by the undertaking of the surveillance program. The public wanted to know what was going on in relation to their particular concerns. However, now that the incinerators have been operating for several years, and results have suggested that the incinerators are effective at controlling emissions, the impact of the program on the public opinion is no longer as significant.

Dr. Reis concludes by stating that she believes the environmental surveillance programs currently in place are adequate to ensure the protection of public health and the environment, particularly the human biomonitoring programs, as these give the best measure of the real human exposure and provide the only means of relating human exposure with potential associated adverse health effects.

5.4.3.2 Dr. J.L. Domingo, Laboratory of Toxicology and Environmental Health, Rovira i Virgili University, Spain

Dr. Domingo (personal communication, November 4, 2008) has been involved in human health surveillance programs for approximately 20 years, and since 1995, has focused on programs relating to the environmental and human health impact of toxic pollutant emissions by municipal and hazardous waste incinerators.

> ***Relevance to Current Study***
>
> Dr. Domingo has conducted numerous environmental and human biomonitoring programs surrounding incineration facilities for the past 20 years.
>
> His research team provides results that have served to alleviate public concern surrounding many of these facilities.

Catalonia, an autonomous community of Spain, is a small country of approximately 7.4 million people. Within its borders lies 6 municipal solid waste incinerators (MWI) and one hazardous waste incinerator (HWI - the only one in all of Spain). These facilities are regulated by the Catalonian Environment Department, which has a specific branch, the Agency of Waste, dedicated to issues concerning these facilities. There are no specific legislative requirements for MWIs to conduct environmental surveillance; however Dr. Domingo notes that most of the facilities have at one time conducted some form of study to assess their impact on the environment and human health. On the contrary, the HWI has a specific surveillance program due to community concern that was raised by the general population.

The HWI, and the MSWIs that conduct surveillance, have taken measurements of metals, dioxins and furans in air, soil and vegetation near the facility. Biological samples, such as blood, hair, breast milk and plasma were also taken at the HWI. The results of these surveillance programs are generally used to conduct risk assessments focused on the facilities. These programs are financially supported by the government, and in the case of the MWIs, also by the facility's themselves. All results from these studies are published in the scientific literature, in order to assure the scientific credibility of the studies in the eyes of the public. Similar reports are also prepared for the facilities themselves. Overall, the research group led by Dr. Domingo accounts for nearly 25% of all the scientific literature papers extracted and analyzed in this review – a significant number.

There are no documented best practices for these types of programs in place from any regulatory bodies, and the programs used by Dr. Domingo and his team of researcher are self-designed, approved by government and accepted by the facilities. The studies have provided useful and measureable results, and have led to a significant decrease in public pressure against the incinerators in question. As discussed in the scientific literature review, the general results of these programs have been to show that there are little to no measurable effects in the environment or in the surrounding public.

To his knowledge, and based on the activity of his group, while there are certainly individual studies published on this topic, there are no other true environmental surveillance programs surrounding incineration facilities in the world. The Study Team is not certain if he is aware of the work being done by Dr. Reis in Portugal.

Dr. Domingo, based on his experience, concludes by recommending the establishment of a surveillance program, initiated prior to facility construction in order to establish a baseline. He also recommends the creation of a committee of community leaders to follow the results of the program.

5.4.3.3 Dr. Greet Schoeters, VITO, Belgium

Dr. Schoeters (personal communication, December 5, 2008) has been involved in the field of human biomonitoring for approximately 10 years. To her knowledge, incineration facilities in Belgium are regulated at the stack (emissions), however facilities are not required by law to do any environmental surveillance or monitoring. Incinerators in Belgium are required to meet the regulations of the European Directive, and environmental legislation is established at the regional level (in this case, the Flemish public administration).

Relevance to Current Study

Human biomonitoring programs in Belgium were initiated as a result of public concern surrounding incineration facilities. To date, no increased levels of environmental contaminants have been found in humans living near modern MWI facilities.

The Flemish administration began supporting a human biomonitoring program to respond to public concern over the impact of industry on public health (incineration facilities representing one component of the program), and where to site industrial facilities. The studies are funded by the public administration.

All methods and results are published on the study group's website, and attempts are made to publish results in the scientific literature when possible. Publishing results aids in reassuring the public of the integrity of the studies and helps ease public concern.

The general outcomes of the studies are that it is difficult to make a direct link between the source of pollution and pollutant levels in the human body. Residents surrounding eight incinerators were studied and in general, no increased levels of the pollutants studied were found but exceptions exist where historical contamination is present from older incineration facilities. Dr. Schoeters' current work focuses on human biomonitoring of hot spots where contamination might exist.

5.4.3.4 Dr. Laura Green, Cambridge Environmental, United States

Dr. Green (personal communication, December 5, 2008) has been involved in EFW projects for around 25 years. The regulatory framework in the U.S. has had a complex history. Currently, it is based on maximum achievable control technology (MACT) and the federal government (U.S. EPA) has set regulatory emissions levels for pollutant levels at the stack. In some States, the levels may be lower based on public or political pressure.

> ***Relevance to Current Study***
>
> The US EPA and individual States set emissions limits at the stack and stack monitoring requirements for facilities.

American facilities themselves typically don't conduct environmental monitoring because it is assumed that if they are meeting the prescribed emissions limits, then they are in effect being protective of the environment. There is little incentive for these facilities to go above and beyond this duty. Newer facilities emit such small levels that it would be difficult to design a sampling program today that could accurately find a link between levels in the environment and the facility itself.

5.4.4 Summary of Findings of the External Contact with Experts in the Field of Environmental Surveillance of Incineration Facilities

The Study Team was fortunately to be able to interview a number of experts in the field of environmental surveillance, and in particular those surrounding incineration facilities. The discussions and responses to questionnaires served to reiterate the various practices of environmental surveillance surrounding incineration facilities around the world.

With the exception of Portugal and some areas of Spain, the majority of countries and regulatory bodies mandate stack testing and monitoring of chemical parameters at incineration facilities. The primary driver behind this being the belief that air dispersion modelling and human health risk assessment, in combination with stack testing/monitoring are sufficient to ensure the protection of human and environmental health. Portugal appears to be the only country that commonly mandates a more resource intensive environmental surveillance program, often in the form of human and environmental monitoring.

In those instances, such as in Spain and Portugal, where more extensive environmental surveillance programs have been put in place at individual facilities public concern over facility emissions appears to have been the impetus behind the program initiation.

6.0 SUMMARY OF INTERNATIONAL PRACTICES OF ENVIRONMENTAL SURVEILLANCE FOR INCINERATION FACILITIES

Upon completion of the scientific literature review, the grey literature review, and the external contact review, the Study Team has compiled a summary of practices of environmental surveillance by country. A common aspect of all global environmental surveillance programs surrounding incineration facilities is the legislation of stack emissions and the requirements for continuous monitoring, coupled with periodic stack testing, of chemical emissions.

The following section provides information on stack emissions regulations by country, a more in depth discussion on the Certificate of Approval Requirements for Ontario incineration facilities, and finally a summary table of current practices of environmental surveillance by country.

6.1 Stack Emission Regulations for Incineration Facilities

6.1.1 Canada

Canada has assigned jurisdiction over incineration facilities to the individual provinces. The Canadian Council of Ministers of the Environment (CCME, 2008) has established stack emissions guidelines, which are not specific to any one industrial facility, for PCDD/F and mercury, with guidelines for particulate matter ($PM_{2.5}$) and ozone to come into effect in 2010. However, these guidelines are not codified into law – they merely serve as a guideline for provinces to establish environmental regulations outlining maximum emissions levels.

Specifically in Ontario, new municipal waste incinerators of any size must conform to Guideline A-7 - Combustion and Air Pollution Control Requirements for New Municipal Waste Incinerators (Ontario Ministry of the Environment, 2004). The Guideline provides fixed emission limits for a number of pollutants (particulate matter, cadmium, lead, mercury, dioxins and furans, hydrochloric acid, sulphur dioxide, nitrogen oxides, and organic matter). These limits are based on the maximum achievable control technology (MACT) or lowest achievable emission rate principles and are designed to ensure the protection of both human health and the environment. Facilities are required to prove compliance with the standards within six months of start-up under maximum operating feed rates, and thereafter, at a minimum of once a year. The guideline encourages the implementation of a continuous stack monitoring system, but does not mandate it. Approved facilities are issued a Certificate of Approval (C of A) that outlines the emission limits that the facility must meet, the frequency with which they must prove compliance and the methods and procedures by which they will achieve this. Details on CofA for operating Ontario facilities are provided in Section 6.2.

6.1.2 United States

The US EPA has established emission limits for new municipal waste combustors as of May 2006 (United States Federal Register, 1995; United States Federal Register, 2006). These limits are codified into law; however, implementation of these limits is left to State jurisdiction. That is, every State must, at a minimum, require that incinerators within their jurisdiction meet the US EPA emission limits for incineration facilities.

The individual States are free however to impose stricter limits than those put forth by the US EPA. Chemicals included in the regulation are the same as those included in Ontario, with the exception of organic matter. Continuous emissions monitoring systems are required for the measurement of SO_2 and NO_x, and are optional for the measurement of PM and Hg. Other potential pollutants are expected to be tested at the stack annually. Results are expected to be reported on an annual basis for all parameters.

6.1.3 European Union

Incineration facilities in the European Union are regulated by Directive 2000/76/EC (Official Journal of the European Communities, 2000), which aims *"to prevent or to limit as far as practicable negative effects on the environment, in particular, pollution by emissions into air, soil, surface water, and groundwater, and the resulting risks to human health, from the incineration and co-incineration of waste."* The directive describes incineration and co-incineration differently based on the main purpose of the facility. If the main purpose is the thermal treatment of waste, with or without heat recovery, the facility is deemed an incineration facility. Concurrently, if the facility's main purpose is the generation of energy, using waste as a fuel, the facility is deemed a co-incineration facility and must meet different emissions limits. However, where the co-incineration facility uses untreated mixed municipal waste as a fuel, the emission limits for incineration facilities are used. Therefore, for the purposes of this discussion, the emission limits for incineration facilities in the European Union will be deemed most applicable.

Continuous stack measurement of all described pollutants in the Directive is mandated with the exception of metals and PCDD/F, which are required to be stack tested at minimum twice per year. Depending on the results of previous tests, this frequency may be diminished for future tests. Any incineration facility in a member nation of the European Union must meet the minimum emission limits set out in Directive 2000/76/EC; however, member nations are free to mandate stricter emissions limits for their facilities.

6.1.4 Hong Kong

Hong Kong is an example of a nation that has looked to the European Union for direction. The emissions limits, as well as continuous and periodic monitoring regulations, for incineration facilities in Hong Kong are identical to those of Directive 2000/76/EC (Hong Kong Environmental Protection Department, 2008).

6.1.5 Taiwan

Taiwan, has established its own standard emission limits for incineration facilities. Incineration facilities are required to continuously monitor particulate matter and carbon monoxide, and report these results on a monthly basis. All other pollutants are sampled and reported twice annually, 3-9 months apart, and not following annual facility cleaning. All testing dates, methods and procedures must be released to the public at a minimum of seven days prior to testing (Taiwan Environmental Protection Administration, 2003; Taiwan Environmental Protection Administration, 2006).

6.2 Current Monitoring Requirements of Canadian Incineration Facilities

A small number of energy-from-waste or incineration facilities operate in Canada. As a component of the grey literature review, the monitoring requirements for the identified facilities were obtained. A copy of all Certificates of Approval or other documents that identify the surveillance requirements for each facility is provided in Appendix E.

6.2.1 Example of Canadian Municipal Waste Incinerators Regulatory Requirements

6.2.1.1 Algonquin Power Energy-From-Waste Facility, Peel Region, ON

The Ontario Ministry of the Environment (MOE) Certificate of Approval (CofA) for the Algonquin Power Energy-From-Waste Facility in Oakville, Ontario was obtained through a request to the MOE. Based on this information, the facility is required to meet the emissions guidelines set out in Ontario Guideline A-7. Continuous monitoring devices are required for monitoring of hydrogen chloride, NO_x, opacity and temperature, at locations specified in the Certificate of Approval. Further to this, stack testing is required for a variety of gases, particulate matter, metals, chlorinated organic compounds, polycyclic organic compounds and volatile organic compounds, as specified in the Certificate of Approval.

In 2001, the CofA also required that surficial soil sampling be conducted at 10 sites surrounding the facility beginning in 2002. Samples are to be collected every three years and analyzed for cadmium, lead, mercury, chromium and nickel, and results compared to data collected in 1986. The CofA acknowledges that "*the limited sampling opportunities and the rapid changes in the area likely preclude any chance of establishing a cause effect relationship between the facility and ambient conditions, but the study will confirm if there have been any changes, and provide a baseline for future assessments*".

The Study Team obtained a copy of the latest report that details the results of the program in 1986, 2002, 2005 and 2008 (Pollutech, 2008). Of the 10 sample locations mandated in the CofA by the MOE, only 1 is located within 1 km of the facility (P-1), three are located within 2 km of the facility (P-2, P-3 and P-9), with the remainder located between three and ten kilometers from the facility. Based on the findings of our systematic review of soil monitoring programs, such a soil sampling program could be better designed, with the majority of sample locations between the fence-line of the facility out to a distance of 1 km. This would allow for better assurances of establishing a cause-effect relationship between the facility and ambient conditions. Location P-1, situated within 1 km northwest of the facility, did not show any changes in concentrations of the five metals analyzed over the six year period.

In addition, a liaison committee was formed, consisting of volunteers from the region, facility representatives, and staff from the Region and the MOE (Region of Peel, 2008). The liaison committee serves as a forum for concerned members of the public to provide feedback on the facility, as well as a review body for monitoring or other reports published by the facility and the MOE.

6.2.1.2 Greater Vancouver Regional District Energy-From-Waste Facility, Burnaby, BC

The Greater Vancouver Regional Solid Waste Management Plan (1995) was consulted to identify the monitoring requirements for the Burnaby Incinerator, which has been in operation for over 20 years. Monitoring is overseen by the Source Monitoring Subcommittee of the Technical Review Committee, which is composed of the BC Ministry of the Environment, Environment Canada, the Metropolitan Board of Health and the Greater Vancouver Regional District.

Emissions limits are in place for particulate matter, carbon monoxide, SO_2, NO_x, HCl, HF, total hydrocarbons, metals (mercury, cadmium, lead, etc.), PAHs, and PCDD/F. With the exception of lead, these emissions limits are equivalent or higher than those found in Ontario Guideline A-7. Continuous monitoring is mandated for opacity, carbon monoxide, SO_2, NO_x. The facility also continuously monitors but is not required to report levels of HCl and ammonia. In some cases, continuous monitoring of these parameters is used as a surrogate for other parameters between manual stack testing events. Annual manual stack testing events are required for all other parameters (particulate matter, metals, total hydrocarbons, etc.).

However, the facility exceeds their mandated requirements, and conducts manual stack testing three times annually, in triplicate each round (Personal Communication, Chris Allan, January 9, 2009). As well, while there is no regulatory requirement for the facility to monitor PCDD/F, the BC Ministry of the Environment may, at their request, require the facility to conduct manual PCDD/F stack tests. While this request has not been made recently, the facility conducts stack testing for PCDD/F every two years regardless according to the CCME Canada-Wide Standards. Other organics, such as PAHs, PCBs, and HCB are occasionally tested at the facility's discretion to ensure that nothing has changed operationally. A monthly report of all continuous monitoring results and any manual stack testing results is mandated, along with an annual report which consolidates and summarizes the monthly data. An environmental monitoring program was in existence when the facility was first operated, but this has been scaled back significantly and is now operated as part of a regional air quality network run by Metro Vancouver. Further details on this program are discussed in Section 5.4.2.3.

If continuous stack monitoring highlights an issue with the facility in real-time, the source of the problem is identified. If the problem is combustion related, the operators adjust combustion parameters to correct the exceedance in real-time. If the problem is not combustion related, then the unit where the problem lies is shut-down and corrected. If an exceedance occurs during manual stack testing, two duplicate tests are completed to ensure that the exceedance was not caused by lab or sampling error. All exceedances are reported to the Ministry of Environment, and it is the Ministry that decides whether or not there is reason for concern.

6.2.2 Example of Ontario Municipal Waste Demonstration and Small Scale Incinerator Regulatory Requirements

6.2.2.1 Plasco Energy-From-Waste Demonstration Facility, Ottawa, ON

The Ontario Ministry of the Environment CofA for the Plasco Energy-From-Waste demonstration facility in Ottawa, ON was obtained from the MOE. The CofA, which was activated on January 27, 2008, states the requirements that the facility must meet in order to remain operational. It should be noted that the current Plasco facility is a demonstration gasification facility, which processes 85 tonnes of municipal waste a day. All facility emissions must meet the standards set out in Guideline A-7. The certificate of approval also outlines Operational Limits for HCl, SO_2, organic matter, particulate matter, and PCDD/F. These limits are lower than the maximum limits as specified in Guideline A-7. If at any time these operational limits, or the Guideline A-7 limits for other chemicals, are exceeded for more than one hour then the facility must be shut down and emission discharge ceased.

The facility must install a continuous emissions monitoring system prior to the opening of the facility for the recording of temperature, CO, O_2, NO_x, HCl, SO_2 and organic matter levels, with monitoring locations specified in the CofA. Other parameters, such as metals, PCDD/F, are to be manually sampled and tested at the source. Facility engineers must submit a monthly report outlining the results of the continuous emissions monitoring system, as well as the results of any source testing conducted in that month. Source testing must have been completed at 3 months and 6 months after start up of the facility.

In monitoring reports produced, the facility must also conduct dispersion model calculations based on the stack testing results to determine the concentrations at a selected point of impingement (the point outside the property boundaries at which the highest concentration is expected to occur, calculated according to the AERMOD model). Beyond this, as this is a demonstration facility, any source testing requirement is at the discretion of the MOE District Manager. No mention is made of any requirement for environmental surveillance. The monthly engineering reports are publically available on their website at http://www.zerowasteottawa.com/en/Trail-Road/.

6.2.2.2 Enquest Power Corporation Pilot Gasification Plant, Sault Ste. Marie, ON

The CofA was obtained from the MOE for a pilot plant involving gasification of coal and thermal treatment of materials including paper and domestic waste. The CofA states that the facility must meet the emissions guidelines established in Ontario Guideline A-7. The Certificate also outlines minimum removal efficiencies for metals that must be met. A number of other parameters (including metals, and volatile organic compounds) must be monitored but no strict emissions guideline has been established or must be met. Continuous monitoring equipment must be operational for the monitoring of temperature, total hydrocarbons, carbon monoxide and flue gas oxygen.

Single stack testing events are required for the monitoring of all other parameters, and must be conducted during the final testing event at the pilot facility. In monitoring reports produced, the facility must also conduct dispersion model calculations based on the stack testing results to determine the concentrations at a selected point of impingement (the point outside the property boundaries at which the highest concentration is expected to occur, calculated according to Ontario Regulation 419/05).

6.2.2.3 2132656 Ontario Inc. (Remasco) Solid Non-Hazardous Waste Incinerator, Kingsville, ON

The CofA was obtained from the MOE for a solid non-hazardous waste incinerator in Kingsville, Ontario. Waste from the York Region Material Recovery and Transfer Facility is the only waste allowed to be incinerated by the facility, at a rate of no more than 5 tonnes per day. This is a very small facility in comparison to the one being contemplated by the Regions of Durham and York. The CofA states that the facility must meet the emissions guidelines established in Ontario Guideline A-7. A number of other parameters (including metals, and volatile organic compounds) must be monitored but no strict emissions guideline has been established or must be met. Continuous monitoring equipment must be operational for the monitoring of temperature, opacity, carbon monoxide and flue gas oxygen. Single stack testing events are required for the monitoring of all other parameters. In monitoring reports produced, the facility must also conduct dispersion model calculations based on the stack testing results to determine the concentrations at a selected point of impingement (the point outside the property boundaries at which the highest concentration is expected to occur, calculated according to Ontario Regulation 419/05).

6.2.3 **Example of Canadian Non-Municipal Waste Incinerators Regulatory Requirements**

6.2.3.1 Clean Harbors Hazardous Waste Incinerator and Landfill, Sarnia, ON

The Clean Harbors Hazardous Waste Incinerator and Landfill in Sarnia, ON was the first facility of its kind in Canada. It is recognized by the reviewers that this facility is a hazardous waste incinerator and is not directly comparable to the EFW facility proposed by the Durham/York Residual Waste Study.

The requirements of the facility with regards to environmental surveillance for this facility have changed over time, and differ from other incineration facilities in Canada. An environmental assessment was conducted prior to the commencement of landfill operations. Pursuant to this environmental assessment, an environmental surveillance baseline study was conducted. Over time, this baseline study evolved into a regular monitoring program. Many of the requirements are outlined in the MOE CofA for the Landfill and the 2007 Annual Landfill Report. These documents were consulted to identify the monitoring requirements of the facility. The Certificate of Approval outlines the need for monitoring of landfill cap integrity, groundwater, surface water, air quality and biomonitoring. The facility must provide, prior to November 30th of each year, an annual report summarizing the results of monitoring programs for the year amongst other things. Full details of the monitoring programs are contained in the facility's Design and Operations Report.

Specifically with regard to emissions from the incineration facility, daily efficiency tests are required for organic matter, carbon monoxide, particulate matter and opacity. These tests ensure that the facility is meeting minimum efficiency requirements and ensure that the facility is fit to operate. Specific targets for these parameters are similar to those outlined in Guideline A-7 (for municipal waste incinerators). Further to this, annual stack testing is done for a variety of commonly observed parameters such as PCDD/F, and metals.

In addition, there are environmental monitoring requirements that encompass both the landfill activities, as well as the incineration facility. Annual air quality monitoring is conducted at the fence line of the facility, on days of suitable meteorological conditions. Finally, the annual environmental monitoring program uses a network of test sites up to 2 km from the facility. The program includes sampling of soil, ditch sediment, natural grass vegetation, and agricultural crops. Chemicals assessed in the environmental monitoring program include metals, organochlorine pesticides, PCBs, dioxins and furans. Over the 15 years of conducting the environmental monitoring program there have been no reported changes in environmental conditions surrounding the facility. The Clean Harbours website provides information and annual reports at http://www.cleanharbors.com/locations/lambton/information_resource_centre.html

6.2.3.2 Liberty Energy Inc. Energy-from-Waste Facility, Hamilton, ON

Liberty Energy Inc. obtained a CofA from the MOE in September of 2008 for the operation of a gasification facility (using biosolids and biomass as fuel) to generate 10 MW of electricity. This plant is not yet operational. Emissions guidelines are established only for particulate matter (more lenient than Guideline A-7), mercury (more lenient than Guideline A-7) and PCDD/F (identical to Guideline A-7). All other parameters must meet the Ontario Ministry of the Environment Point of Impingement Limits established in Ontario Regulation 419/05. Continuous monitoring is required for temperature, opacity, carbon monoxide, flue gas oxygen, hydrogen chloride and NO_x. The facility must also conduct, within 6 months of operations commencing, monitoring results for particulate matter, hydrogen chloride, mercury, dioxins and furans, acrolein, bis(2-ethylhyxy)phthalate, chloroform, sulphur dioxide, formaldehyde, nickel and polycyclic organic matter. Further to this, dispersion calculations must be undertaken to determine concentrations at a selected point of impingement.

6.3 Summary of Global Environmental Surveillance Requirements for Incineration Facilities

Though it is difficult to make generalized worldwide claims as to the practices of environmental surveillance around incineration facilities, some notable trends are apparent. Most countries were identified to govern incineration facilities similarly to the Canadian approach – at the regional/provincial/state level. In almost all cases, prior to project approval an environmental assessment is required to determine whether the facility could adversely impact air quality, human and environmental health. The majority of facilities around the world conduct only stack monitoring programs, with the exception of Portugal where environmental monitoring and human biomonitoring programs may be mandated under the operating permits of individual facilities.

This review found that older incineration facilities and/or those with less advanced or no air pollution control technology may have impacted the environment immediately surrounding the facility. The study result indicate that a modern MWI facility, such as the one being proposed by the Regions of Durham and York, that employ maximum achievable control technology for air pollution, would be unlikely to impact the health of local residents or the environment.

TABLE 6-1 SUMMARY OF ENVIRONMENTAL SURVEILLANCE PRACTICES ON A COUNTRY-BY-COUNTRY BASIS FOR MWI . AN X WAS USED TO DENOTE A GOVERNMENT REQUIREMENT – EITHER LEGISLATED OR AS PART OF INDIVIDUAL FACILITY OPERATING REQUIREMENTS

Country	Municipal Waste Incinerators							
	Continuous Stack Monitoring	Periodic Stack Testing	Periodic Ambient Air Monitoring	Continuous Ambient Air Monitoring	Soil Monitoring	Vegetation Monitoring	Agricultural Product Monitoring	Human Biomonitoring
Canada	X	X						
Ontario	X	X			X			
United States	X	X						
European Union	X	X						
Portugal	X	X	At some locations	At some locations				At some locations
Spain	X	X	At some locations	At some locations				
Belgium	X	X						
Germany	X	X						
Italy	X	X	At some locations	At some locations				
Sweden	X	X						
Taiwan	X	X						
Korea	X	X						
Japan	X	X						
Hong Kong	x	X						

7.0 STUDY TEAM RECOMMENDATION FOR ENVIRONMENTAL SURVEILLANCE OF THE DURHAM/YORK EFW FACILITY

The objective of this review was to consolidate the findings of legislated practices, and scientific studies that have been carried out around the world, into a Study Team recommendation for an environmental surveillance program that could be implemented for the proposed Durham/York EFW facility.

As stated in the Study Protocol:

> *"The consultant's recommended option for an environmental surveillance program for the proposed Durham/York Residual EFW facility will be based on the fundamental tenant that the program must ensure the protection of public and environmental health."*

Overall, there was a great deal of consistency between the environmental surveillance options (Figure 2-1) reported in the scientific literature, the grey literature and through external contact interviews with experts in the field. On this basis the Study Team believes that it is unlikely that additional information may have been missed during this review, which would alter our findings, conclusions or recommendations.

Globally the government legislative requirement for environmental surveillance of MWI facilities is continuous and periodic testing of chemical emissions at the stack. The adoption of this level of surveillance for a modern MWI facility, that would incorporate maximum achievable pollution control technology (MACT), was deemed by the Study Team to be scientifically justified to ensure the protection of both human and environmental health. Continuous stack monitoring of a limited number of chemicals (e.g., NO_x and SO_2) are used as surrogates for other chemical parameters between periodic manual stack testing events. This level of environmental surveillance ensures that the facility is operating within its purported emissions control limits for all chemicals.

In the event that continuous stack monitoring highlights an issue with the facility emissions in real-time, the source of the problem is identified. If the problem is combustion related, the operators adjust combustion parameters to correct the issue in real-time. If the problem is not combustion related, then it is possible that the unit where the problem lies can be shut-down until the problem is rectified. Exceedances of emissions limits would be required to be reported to the MOE. It would be the responsibility of the MOE to verify that proper steps have been taken to rectify the issue with facility operators.

As stated in Section 2, in order to establish an appropriate level of environmental surveillance for an EFW facility one must first understand the manner in which it will be granted approval for operation. The proposed Durham/York EFW facility is currently undergoing a rigorous Individual Environmental Assessment process as laid out in the Minister's Approved Terms of Reference (TOR). It is the most comprehensive EA Study that has been completed for an EFW facility in Ontario, and will have taken almost five years to complete.

As part of the Durham/York Residual Waste Study a comprehensive site-specific baseline environmental chemical program that measured existing concentrations of chemicals in air, water, soil, vegetation, produce, agricultural products, fish and wildlife was conducted at the proposed location of the Project. In most countries, and in the scientific literature, a great deal of emphasis is placed on the collection of baseline chemical concentrations in environmental media. As was conducted for the Durham/York Residual Waste Study, the review determined that environmental samples should be collected in close proximity (with 1 km radius) of a facility. This is where the maximum zone of deposition of chemicals from incineration stack emissions were reported. If necessary, this chemical baseline provides the basis on which subsequent monitoring programs can be compared.

In addition, the technical component studies to the EA Study will include a site and vendor-specific Air Quality dispersion and deposition modeling study and a Site-Specific Human Health and Ecological Risk Assessment (HHERA). These studies will be designed to overestimate the potential exposure of humans and ecological receptors to EFW facility chemical emissions. Prior to the Minister granting EA approval and issuing a Certificate of Approval (CofA) that will govern the operation of the facility, these component studies will be required to demonstrate that there will be no undue risk to human or ecological health from exposure to chemicals emitted from the facility. Therefore, stack testing chemical emissions once the facility becomes operational will ensure that conservative emissions estimates used in the modelling are not exceeded, thus no risk to human or ecological health would be expected.

The Study Team originally envisioned the inclusion of an initial cost estimate for each of the environmental surveillance options. However, it became apparent during the review process that inclusion of costs could potentially bias the selection of a scientifically-based optimal option for the protection of public and environmental health. Therefore, costs were excluded from consideration in this review and can be provided once a preferred option is adopted by Durham Regional Council.

Through the grey literature review and external contact survey, another key component to environmental surveillance of incineration facilities was reported to be the establishment of an independent facility-specific oversight committee. Such a committee exists for the Algonquin Power EFW Facility located in Brampton, Ontario (Region of Peel). The committee includes volunteers from the local community (including the co-chairs), representatives from the facility, and staff from Region of Peel and the MOE. The committee was formed in 1992 and meets regularly to discuss plant performance, annual compliance testing, new technologies and potential concerns. They are also tasked with providing residents feedback to facility staff and the government.

In 2008, as part of the Durham/York Residual Waste Study a Site Liaison Committee (SLC) was established to review and provide input on site specific studies related to the EA Study of the proposed EFW facility. The committee includes volunteers from the Region of Durham (including the chair) and residents of Clarington, with non-voting members that include Councilors and staff. In part, the SLC scope of activities includes:

- Facilitating communication between local residents and stakeholders, and the Joint Waste Management Group; and,
- Receiving and hearing deputations from local residents and stakeholders pertaining to the EFW site specific EA studies.

The terms of reference for the committee state that the term of the SLC will continue through to the formal conclusion of the EA process, at which time it will be dissolved. However, at that time the terms of reference indicate that a new committee will be struck with a new mandate for the construction, operation and monitoring for the EFW project. Regardless of which environmental surveillance option is ultimately put in place, it is proposed by the Study Team that this committee be charged, in part, with review of any environmental surveillance program being undertaken for the Durham/York EFW facility.

This would ensure public participation in the environmental surveillance program and evaluation of its efficacy in protecting public and environmental health.

Supported by the scientific findings of our review, the Study Team recommends that the following environmental surveillance option be considered for implementation by the Regions of Durham and York for their proposed EFW facility.

7.1 Study Team Recommended Environmental Surveillance Option Option 1 – Chemical Emissions Stack Monitoring and Testing

Option 1 a) Compliance with Ontario Guideline A-7 Combustion and Air Pollution Control Requirements for New Municipal Waste Incinerators

This represents the minimum level of environmental surveillance and monitoring to which the EFW facility must commit. This will ensure the protection of the surrounding environment and conform to the regulatory requirements associated with the operation of such a facility in Ontario. Guideline A-7 stipulates the combustion and air pollution emissions and monitoring requirements for municipal waste incinerators operating in Ontario and forms the basis of issuing the CofA by the MOE.

Guideline A-7 sets out fixed emission limits for nine (9) parameters: particulate matter, cadmium, lead, mercury, dioxins and furans, hydrochloric acid, sulphur dioxide, nitrogen oxides and organic matter. The facility is required to prove compliance with the standards within six months of start-up under maximum operating feed rates, and thereafter, at a minimum of once a year. This is accomplished via annual emissions sampling at the stack, under maximum operating feed rates, in accordance with the methods and procedures documented in the Ontario Source Testing Code (Procedure A-1-1).

Continuous stack monitoring of the combustion gases CO, O_2, NO_x, HCl and SO_2 should be considered, with at a minimum annual source testing of additional contaminants such as PCDD/F, VOCs, PM, metals and PAHs. These requirements would be negotiated with the MOE and implemented through inclusion of terms and conditions in the facility's CofA (Air).

This level of environmental surveillance allows for early detection of any potential upset conditions, which can be corrected by facility operators or result in shut-down if stack emissions are above those permitted in the CofA. A robust, continuous stack monitoring of combustion gases, in combination with annual source testing would ensure that chemical concentrations used in the risk assessment are being achieved. This level of environmental surveillance was found to be in place at all incineration facilities in the EU, US and Canada.

Option 1b) Establishment of More Stringent Stack Chemical Emissions Standards than Provided in Guideline A-7

Based on a motion passed at Durham Regional Council, the Request for Proposal (RFP) for vendors stipulates that the lower of the Ontario Guideline A-7 or EU Directive chemical emissions standards will form the basis for the proposed CofA governing emissions limits for the facility (Table 7-1). This level of environmental surveillance would provide an additional level of protection for humans and the environment surrounding the proposed facility.

TABLE 7-1 THE REGIONS' AIR EMISSION CRITERIA BASED UPON THE PROVINCE OF ONTARIO AND EUROPEAN UNION AIR EMISSION REQUIEMENTS AS PROVIDED IN THE RFP TO VENDORS

Pollutant	Units (1)	Ontario Guideline A-7	EU Directive 2000/76/EC EU Limits	YD EFW Stack Emission Limits	Measurement Basis (see Notes)
Total Particulate Matter	mg/Rm^3	17	9	**9**	(2)
Sulphur Dioxide (SO_2)	mg/Rm^3	56	46	**35**	(3)
Hydrogen Chloride (HCl)	mg/Rm^3	27	9	**9**	(4)
Hydrogen Fluoride (HF)	mg/Rm^3	Not Specified	0.92	**0.92**	(4)
Nitrogen Oxides (NO_X)	mg/Rm^3	207	183	**180**	(4)
Carbon Monoxide (CO)	mg/Rm^3	Not Specified	46	**45**	(4)
Mercury (Hg)	$\mu g/Rm^3$	20	46	**15**	(2)
Cadmium (Cd)	$\mu g/Rm^3$	14	Not Specified	**7**	(2)
Cadmium + Thallium (Cd + Th)	$\mu g/Rm^3$	Not Specified	46	**46**	(2)
Lead (Pb)	$\mu g/Rm^3$	142	Not Specified	**50**	(2)
Sum of (As, Ni, Co, Pb, Cr, Cu, V, Mn, Sb)	$\mu g/Rm^3$	Not Specified	460	**460**	(2)
Dioxins	pg/Rm^3	80	92	**60**	(2)
Organic Matter (as CH_4)	mg/Rm^3	66	Not Specified	**49**	(2)

NOTES:
(1) = All units corrected to 11% O_2 and adjusted to Reference Temperature and Pressure
mg/Rm^3 = Milligrams per Reference Cubic Metre (25^0 C, 101.3 kPa)
$\mu g/Rm^3$ = Micrograms per Reference Cubic Metre (25^0 C, 101.3 kPa)
Pg/Rm^3 = Picograms per Reference Cubic Metre (25^0 C, 101.3 kPa)
(2) Calculated as the arithmetic average of 3 stack tests conducted in accordance with standard methods
(3) Calculated as the geometric average of 24 hours of data from a continuous emission monitoring system
(4) Calculated as the arithmetic average of 24 hours of data from a continuous emission monitoring system

Option 1c) Inclusion of New Stack Sampling Technology for PCDD/F not Routinely Implemented in Ontario EFW or Incineration Facilities

Stack emissions of PCDD/F have historically been measured by periodic stack testing (along with other contaminants of concern). Since there is a heightened public awareness of PCDD/F emissions from EFW facilities, a considerable amount of research has been focused on development of methods for more frequent sample collection and analysis of stack emissions of PCDD/F.

Technology now exists for continuous sampling (not monitoring) of PCDD/F in stacks. In-stack PCDD/F concentrations are sampled for a period of time at regular intervals (e.g., once a month, quarterly, or semi-annually). The sample media is removed, sent for laboratory analysis of PCDD/F and replaced in the stack. The advantage of this technology is that more frequent sampling of PCDD/F can be achieved for an EFW facility.

Based on a motion passed at Durham Regional Council, the Request for Proposal (RFP) for vendors stipulates that some form of continuous PCDD/F sampling and periodic analysis must be included in the design and operation of the proposed EFW facility.

Although this technology was not included as part of this review, the Study Team believes that it would provide additional information to ensure that PCDD/F concentrations used in the risk assessment are being achieved.

8.0 ADDITIONAL LEVELS OF ENVIRONMENTAL SURVEILLANCE NOT RECOMMENDED BY THE STUDY TEAM

Although the Study Team concluded that the most scientifically defensible environmental surveillance option to ensure the protection of public and environmental health was stack monitoring and testing (Option 1), there are additional environmental surveillance options being employed around the world at individual incineration facilities.

These options include:

- Option 2: ambient air monitoring:
- Option 3: environmental monitoring (soil, vegetation, agricultural products); and,
- Option 4: human biomonitoring.

During the review, the Study Team concluded that a modern municipal waste incinerator that would employ the maximum achievable pollution control technology (MACT), would not significantly increase contaminant levels in the environment. This was supported by the scientific literature, the grey literature and the external contact interview process.

Studies that reported significant increases of pollutants in environmental media were predominately conducted on older incineration facilities, and in many cases on those facilities that had different feedstock (e.g., hazardous waste) than would be permitted for the municipal waste incinerator proposed for Durham/York. To date, human biomonitoring studies have not reported a statistical increase in human tissue chemical concentrations as a result of exposure to a municipal waste incinerator.

The impetus for these environmental surveillance programs was reported to be a combination of academic interest and/or a heightened level of public concern surrounding an individual facility. Scientific methods used to gauge public concern surrounding these facilities were not reported, and did not appear to have been carried out by the authors or government officials. The Study Team acknowledges that these are indeed valid societal reasons for policy makers to trigger additional levels of environmental surveillance. However, we felt that it was not appropriate for the Study Team to presuppose or gauge the level of public concern surrounding the Durham/York proposed EFW facility.

If based on perceived public concern, policy makers believe that an additional level of environmental surveillance is warranted, we recommend that this be supported through scientific means such as a polling exercise. Experts in this area of study should be retained by the Regions to develop an appropriate tool for such an assignment.

Although not recommended for implementation, the Study Team has provided a range of additional surveillance options, with each successive level also intended to include all preceding options. Recommendations for what would trigger a more resource intensive surveillance program have been also been included for consideration.

8.1 Environmental Surveillance Option 2 – Ground-Level Ambient Air Monitoring

Option 2a) One Year Ground-Level Ambient Air Monitoring for Target Chemicals

The results of the site and vendor-specific HHERA to be prepared for the EA Study will be based on air dispersion model predicted ground level concentrations and deposition rates. These model predictions are based on conservative science of air modeling and typically have an accuracy of better than a factor of two. However, an environmental surveillance program to validate the air dispersion model predictions used in the risk assessment could be undertaken during the first year of facility operation.

To ensure that contaminant measurements reflect the EFW facility emissions and dispersion, target compounds could include PCDD/F, PAHs and perhaps some metals. Sampling would be conducted in the vicinity of the modelled maximum point of impingement (MPOI) for the facility (as practicable). Given the nature of these contaminants, periodic sampling would be conducted and the measured ground level concentrations would be compared to the predicted air modelling results from the EA Study. The MOE typically requires that a minimum number of valid measurements (samples for which the monitoring was measuring the impact of the target facility) be taken in order to provide an adequate comparison. The number of samples to be collected may be dependent on the sampling methodology, contaminant and cost, and are usually discussed with the MOE prior to program implementation. This would affect the frequency with which the ambient monitoring would be conducted. If good agreement with modelled results is found after the first year of sampling then the program could be discontinued.

This option for environmental surveillance did not appear to be frequently undertaken for many facilities, unless mandated by the findings of the EA process or included in individual facility permits.

Option 2b) Longer-term Ground-Level Ambient Air Monitoring for Target Chemicals

This environmental surveillance option would be a variation of Option 2a, except that the program would be carried out for three to five years. This surveillance option would provide additional assurance that monitored stack emissions (Option 1) do not result in elevated ground level concentrations of contaminants. If good agreement is found with modelled results over the course of three to five years then the program could be discontinued.

This option could be triggered for implementation if stack emissions monitoring results were consistently higher than those used in the EA Study, the air quality modelling study and the risk assessment. In addition, this option could be triggered in the unlikely event that Option 2a was unsuccessful at achieving good agreement with modelled results over a one year period.

Option 2c) Establishment of a Permanent Air Quality Station

This environmental surveillance option would entail the establishment of a permanent ambient air quality monitoring station in the vicinity of the MPOI. Continuous monitoring of the criteria air contaminants (e.g., NO_x, SO_2, $PM_{2.5}$) would be conducted along with periodic sampling of target EFW facility specific chemicals. This monitoring option would provide a continuous record of ground-level contaminant concentrations in the immediate vicinity of the EFW facility over its operational life. This option could be triggered in the event that stack testing and monitoring does not provide sufficient detail to document exposure of humans and environmental receptors to its emissions over its lifecycle.

8.2 Environmental Surveillance Option 3 – Environmental Monitoring Program

Option 3a) Environmental Monitoring of Chemical Concentrations of Soil and Vegetation Surrounding the EFW Facility

This environmental surveillance option would involve collection and chemical analysis of soil and vegetation samples at five to ten locations within 1 km of the EFW facility. The recommended frequency of sampling would not be less than every three years, which would allow for sufficient time for EFW facility chemicals to deposit in the environment.

Chemicals that could be considered for inclusion in such an environmental monitoring program would be PCDD/F, metals and PAHs. Composite soil samples should be collected in the surface soil horizon (0-5 cm) and vegetation (including agricultural crop) samples would be collected at the same location as soil samples. Sample locations should be within the highest predicted zone of deposition influence from the EFW facility and remain consistent from year-to-year.

Statistical comparisons, that would allow for a determination of statistical significance over those already collected as part of the baseline study (pre-operation), should be made to determine if there has been a statistically significant change in environmental conditions.

This surveillance option could be carried out throughout the life of the facility. However, the program could be discontinued if sufficient empirical evidence that chemicals are not increasing in the environment is documented. Alternatively, if significant increases in soil or vegetation chemical concentrations were measured over a three year sampling period, a more frequent sampling program could be implemented.

Although this environmental surveillance option is not recommended by the Study Team, it could be triggered if ambient air measurements (Option 2) had greater than expected contaminant levels detected.

Option 3b) Environmental Monitoring of Agricultural Resources Surrounding the EFW Facility

Similar to Option 3a, this environmental surveillance option would involve collection and chemical analysis of agricultural resources within 1 km of the EFW facility. The recommended frequency of sampling would not be less than every three years, which would allow for sufficient time for EFW facility chemicals to deposit in the environment.

However, during the site-specific chemical baseline program conducted for the Durham/York Residual Waste Study, the only agricultural product located within 1 km of the proposed site was a single beef herd (agricultural crops would be covered under Option 3a). There are no other agricultural products known to be within the predicted zone of maximum influence of the proposed EFW facility location. Therefore, this environmental surveillance option would be of limited value for the proposed facility.

Although this environmental surveillance option is not recommended by the Study Team, it could be triggered in the event that a statistically significant increase in contaminant levels attributed to the facility were detected in local soil and vegetation samples (Option 3a). This is the browse and forage that agricultural products would be exposed to and potentially bioaccumulate chemicals in the foodchain.

8.3 Environmental Surveillance Option 4 – Human Biomonitoring Program

Option 4 Human Biomonitoring of Target Chemicals Specific to EFW Facilities

This environmental surveillance option would involve the establishment of a comprehensive human biomonitoring program for residents living within 5 km of the site. It would attempt to correlate human exposure to EFW facility chemical emissions and measured levels in human tissue(s).

A comprehensive Study Protocol would need to be developed and undergo rigorous ethical review by an external board. The biomonitoring study would need to have a clearly stated objective and an appropriate study design that could scientifically answer the question posed.

Human sampling can be an invasive process, depending on the type of sample collected, and as with any medical procedure, there may be an inherent risk involved to the subject. Combined with the knowledge that biomonitoring itself rarely produces direct health benefits and that incentives should not be provided to participants (to reduce reporting bias), it may make subject recruitment difficult.

The Study Team would strongly recommend that this level of environmental surveillance not be adopted for the proposed Durham/York EFW facility. We do not believe that there would be any trigger that would justify the need for this level of environmental surveillance. Although we respect the research and opinions of those engaged in this type of work, the Study Team believes Option 1 will provide a scientifically justified level of environmental surveillance to ensure the protection of public health.

To date there has been no report of a significant correlation between MWI chemical emissions and levels measured in human tissues in biomonitoring studies. Although the Study Team is aware that many of these human biomonitoring programs have only been in place for 5 to 10 years, we believe that a feasible alternative to conducting a Durham/York EFW facility human biomonitoring program would be to periodically monitor the scientific literature. This literature surveillance would be targeted to find reports of a significant increase in chemical concentrations in people living near modern MWI facilities around the world. Maintaining contact with researchers in this area could provide information ahead of publication. Given that the proposed Durham/York EFW facility would not be operational until at least 2012, this should provide a sufficient period of observation of human biomonitoring activities in other jurisdictions; such as Spain and Portugal.

9.0 CONCLUSIONS OF THE STUDY

A considerable amount of information on best practices in environmental surveillance for incineration facilities from around the world was obtained through a systematic literature review (Section 3), grey literature search (Section 4) and external contact interview process (Section 5). The legislated or government mandated requirements of environmental surveillance were summarized in Section 6.

Overall, there was a great deal of consistency between the environmental surveillance options (Figure 2-1) reported in the scientific literature, the grey literature and through external contact interviews with experts in the field. On this basis the Study Team believes that it is unlikely that additional information may have been missed during this review, which would alter our findings, conclusions or recommendations.

Environmental surveillance options reviewed included stack testing of chemical emissions (Option 1), ambient air monitoring (Option 2), environmental monitoring (soil, vegetation, agricultural products) (Option 3), and human biomonitoring (Option 4).

Ultimately the review determined that a modern municipal waste incinerator that would employ the maximum achievable pollution control technology (MACT) would not significantly increase contaminant levels in the environment. This was supported by the scientific literature, the grey literature and the external contact interview process.

Therefore, the most appropriate and scientifically justified option for environmental surveillance of an EFW facility to be located in the Region of Durham would involve continuous and periodic stack testing of chemical emissions (Option 1). This environmental surveillance option was also found to be the most prevalent method of ensuring public and environmental health protection in Canada, countries of the European Union, and the United States.

In addition to meeting the minimum stack emissions requirements laid out in Guideline A-7, the Study Team supports the decision of Durham Regional Council to:

- Adopt the more stringent of the Guideline A-7 and EU Directive chemical emissions standards; and,
- Implement an in-stack PCDD/F sampling technology.

These measures go beyond any requirements that would have been derived from our review.

Another key component to environmental surveillance of incineration facilities was reported to be the establishment of an independent facility-specific oversight committee. It is proposed by the Study Team that such a committee be formed and charged, in part, with review of any environmental surveillance program being undertaken for the Durham/York EFW facility. This would in no way remove the onus of facility regulation from the Ontario Ministry of the Environment. Rather, it would ensure public participation in the environmental surveillance program and evaluation of its efficacy in protecting public and environmental health.

The findings of the review do not justify implementation of ambient air monitoring (Option 2) or environmental monitoring (soil, vegetation, agricultural products) (Option 3). In addition, we would strongly recommend that human biomonitoring (Option 4) not be adopted for the proposed Durham/York EFW facility. The Study Team does not believe that there would be any trigger that would justify the need for this level of environmental surveillance.

10.0 REFERENCES

Abad, E., Caixach, J., & Rivera, J. (1997). PCDD/PCDF from emission sources and ambient air in northeast Spain. Chemosphere, 35, 453-463.

Agramunt, M. C., Domingo, A., Domingo, J. L., & Corbella, J. (2003). Monitoring internal exposure to metals and organic substances in workers at a hazardous waste incinerator after 3 years of operation. Toxicology Letters, 146, 83-91.

Agramunt, M. C., Schuhmacher, M., Hernandez, J. M., & Domingo, J. L. (2005). Levels of dioxins and furans in plasma of nonoccupationally exposed subjects living near a hazardous waste incinerator. J.Expo.Anal.Environ.Epidemiol., 15, 29-34.

Agrell, C., Ter Schure, A. F. H., Sveder, J., Bokenstrand, A., Larsson, P., & Zegers, B. N. (2004). Polybrominated diphenyl ethers (PBDES) at a solid waste incineration plant I: Atmospheric concentrations. Atmospheric Environment, 38, 5139-5148.

Alberta Health and Wellness (2004). Swan Hills Treatment Centre: Long-term follow-up health assessment program (1997-2002) Alberta, Canada: Alberta Health and Wellness.

Almaguer, D. & Driscoll, R. J. (1991). Health Hazard Evaluation Report No. HETA-88-314-2152, Lutheran Medical Center, Brooklyn, New York. Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-88.-314.-2152., 27.pages., 8.references., %1991..

Ardevol, E., Minguillon, C., Garcia, G., Serra, M. E., Gonzalez, C. A., Alvarez, L. et al. (1999). Environmental tobacco smoke interference in the assessment of the health impact of a municipal waste incinerator on children through urinary thioether assay. Public Health, 113, 295-298.

Bakoglu, M., Karademir, A., & Ayberk, S. (2004). An evaluation of the occupational health risks to workers in a hazardous waste incinerator. J.Occup.Health, 46, 156-164.

Besombes, J. L., Maitre, A., Patissier, O., Marchand, N., Chevron, N., Stoklov, M. et al. (2001). Particulate PAHs observed in the surrounding of a municipal incinerator. Atmospheric Environment, 35, 6093-6104.

Blais, J. M., Froese, K. L., Kimpe, L. E., Muir, D. C., Backus, S., Comba, M. et al. (2003). Assessment and characterization of polychlorinated biphenyls near a hazardous waste incinerator: analysis of vegetation, snow, and sediments. Environ.Toxicol.Chem., 22, 126-133.

Blanch, A. & Bianchi, A. C. (1999). Volatile organic compounds in an urban airborne environment adjacent to a municipal incinerator, waste collection centre and sewage treatment plant. AU - LEACH J. Atmospheric Environment, 33, 4309-4325.

Bobet, E., Berard, M. F., & Dann, T. (1990). The measurement of PCDD and PCDF in ambient air in Southwestern Ontario. Chemosphere, 20, 1439-1445.

Bocio, A., Nadal, M., & Domingo, J. L. (2005a). Human exposure to metals through the diet in Tarragona, Spain: temporal trend. Biological Trace Element Research, 104, 193-201.

Bocio, A., Nadal, M., Garcia, F., & Domingo, J. L. (2005b). Monitoring metals in the population living in the vicinity of a hazardous waste incinerator: concentrations in autopsy tissues. Biological Trace Element Research, 106, 41-50.

Bolt, A. & De Jong, A. P. J. M. (1993). Ambient air dioxin measurements in the Netherlands. Chemosphere, 27, 73-81.

Borrego, C., Miranda, A. I., Coutinho, M., Ferreira, J., & Carvalho, A. C. (2002). Air quality management in Portugal: example of needs and available tools. Environ.Pollut., 120, 115-123.

Burton, N. C., Esswein, E. J., & Marlow, D. (1992). Health Hazard Evaluation Report No. HETA-91-261-2245, Metropolitan Sewer District, Mill Creek Facility, Cincinnati, Ohio. Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-91.-261.-2245., 33.pages., 54 references., %1992..

Caserini, S., Cernuschi, S., Giugliano, M., Grosso, M., Lonati, G., & Mattaini, P. (2004). Air and soil dioxin levels at three sites in Italy in proximity to MSW incineration plants. Chemosphere, 54, 1279-1287.

Cenci, R. M., Sena, F., Filipi, N., Umlauf, G., Beone, G. M., Lodigiani, G. et al. (2007). Monitoring during time of relapses of an incineration plant. In Eleventh International Waste Management and Landfill Symposium.

Chang, M. B., Weng, Y. M., Lee, T. Y., Chen, Y. W., Chang, S. H., & Chi, K. H. (2003). Sampling and analysis of ambient dioxins in northern Taiwan. Chemosphere, 51, 1103-1110.

Chao, C. L. & Hwang, K. C. (2005). Arsenic burden survey among refuse incinerator workers. Journal of Postgraduate Medicine, 51, 98-103.

Chen, H. L., Lee, C. C., Liao, P. C., Guo, Y. L., Chen, C. H., & Su, H. J. (2003). Associations between dietary intake and serum polychlorinated dibenzo-p-dioxin and dibenzofuran (PCDD/F) levels in Taiwanese. Environ.Res., 91, 172-178.

Chen, H. L., Su, H. J., Guo, Y. L., Liao, P. C., Hung, C. F., & Lee, C. C. (2006a). Biochemistry examinations and health disorder evaluation of Taiwanese living near incinerators and with low serum PCDD/Fs levels. Sci.Total Environ., 366, 538-548.

Chen, H. L., Su, H. J., & Lee, C. C. (2006b). Patterns of serum PCDD/Fs affected by vegetarian regime and consumption of local food for residents living near municipal waste incinerators from Taiwan. Environ.Int., 32, 650-655.

Chen, H. L., Su, H. J., Liao, P. C., Chen, C. H., & Lee, C. C. (2004). Serum PCDD/F concentration distribution in residents living in the vicinity of an incinerator and its association with predicted ambient dioxin exposure. Chemosphere, 54, 1421-1429.

Cobb, G. P., Feng, Z., & Kendall, R. J. (1993). Correlations between polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in soils from western Washington. *Toxicological and Environmental Chemistry, 38,* 207-224.

Collett, R. S., Oduyemi, K., & Lill, D. E. (1998). An investigation of environmental levels of cadmium and lead in airborne matter and surface soils within the locality of a municipal waste incinerator. Sci.Total Environ., 209, 157-167.

Commission of the European Communities. (2004). Communication from the Commission to the Council, The European Parliament, The European Economic and Social Committee: "The European Environment & Health Action Plan 2004-2010". 1; COM(2004) 416 final. Brussels. Ref Type: Generic

Commissioning Organization of the UK Environmental Agency. (2003). Incinerator Sector Guidance Note IPPC S5.01. [1]. Briston, UK, UK Environmental Agency. Ref Type: Generic

Coutinho, M., Conceicao, M., Borrego, C., & Nunes, M. (1998). Atmospheric impact assessment and monitoring of dioxin emissions of municipal solid waste incinerators in Portugal. Chemosphere, 37, 2119-2126.

Coutinho, M., Ferreira, J., Gomes, P., Mata, P., & Borrego, C. (2001). Atmospheric baseline levels of PCDD and PCDF in the region of Oporto. *Chemosphere, 43,* 497-500.

Coutinho, M., Pereira, M., Rodrigues, R., & Borrego, C. (2006). Impact of medical waste incineration in the atmospheric PCDD/F levels of Porto, Portugal. Sci.Total Environ., 362, 157-165.

Crandall, M. S., Kinnes, G. M., & Hartle, R. W. (1992). Levels of Chlorinated Dioxins and Furans in Three Occupational Environments. Chemosphere, 25.

De Felip E., Abballe, A., Casalino, F., di, D. A., Domenici, P., Iacovella, N. et al. (2008). Serum levels of PCDDs, PCDFs and PCBs in non-occupationally exposed population groups living near two incineration plants in Tuscany, Italy. Chemosphere, 72, 25-33.

Demond, A., Adriaens, P., Towey, T., Chang, S. C., Hong, B., Chen, Q. et al. (2008). Statistical comparison of residential soil concentrations of PCDDs, PCDFs, and PCBs from two communities in Michigan. Environ.Sci.Technol., 42, 5441-5448.

Den Hond, E. (2006). Biomonitoring Results. In International Symposium Organized by the Flemish Centre of Expertise for Environment and Health VITO.

Domingo, J. L., Schuhmacher, M., Agramunt, M. C., Muller, L., & Neugebauer, F. (2001). Levels of metals and organic substances in blood and urine of workers at a new hazardous waste incinerator. Int.Arch.Occup.Environ.Health, 74, 263-269.

Eitzer, B. D. (1995). Polychlorinated dibenzo-p-dioxins and dibenzofurans in raw milk samples from farms located near a new resource recovery incinerator. Chemosphere, 30, 1237-1248.

Environmental Protection Department of Hong Kong (2002). The Chemical waste treatment centre: Environmental Monitoring Hong Kong, Japan: Environmental Protection Deaprtment of Hong Kong.

Esswein, E. J. & Tepper, A. (1994). Health Hazard Evaluation Report No. HETA-91-0366-2453, Delaware County Resource Recovery Facility, Chester, Pennsylvania. Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-91.-0366.-2453., 34.pages., 38.references., %1994..

Evans, R. G., Shadel, B. N., Roberts, D. W., Clardy, S., Jordan-Izaguirre, D., Patterson, D. G. et al. (2000). Dioxin incinerator emissions exposure study Times Beach, Missouri. Chemosphere, 40, 1063-1074.

Expert Team to Support BIOmonitoring in Europe (ESBIO) (2007). Development of a coherent approach to human biomonitoring in Europe: Coordination Action Priority 3.1 European Commission.

Feng, Y. & Barratt, R. (1999). Distributions of lead and cadmium in dust in the vicinity of a sewage sludge incinerator. J.Environ.Monit., 1, 169-176.

Ferre-Huguet, N., Nadal, M., Mari, M., Schuhmacher, M., Borrajo, M. A., & Domingo, J. L. (2007). Monitoring metals near a hazardous waste incinerator. Temporal trend in soils and herbage. Bull.Environ.Contam Toxicol., 79, 130-134.

Fierens, S., Mairesse, H., Heilier, J. F., Focant, J. F., Eppe, G., De, P. E. et al. (2007). Impact of iron and steel industry and waste incinerators on human exposure to dioxins, PCBs, and heavy metals: results of a cross-sectional study in Belgium. J.Toxicol.Environ.Health A, 70, 222-226.

Fierens, S., Mairesse, H., Hermans, C., Bernard, A., Eppe, G., Focant, J. F. et al. (2003). Dioxin accumulation in residents around incinerators. J.Toxicol.Environ.Health A, 66, 1287-1293.

Frery, N., Volatier, JL., Zeghnoun, A., Sarter, H., Falq, G., Thebault, A. et al. (2008). The French dioxin and incinerators study France: French Institute for Public Health Surveillance (inVS).

Granero, S., Llobet, J. M., Schuhmacher, M., Corbella, J., & Domingo, J. L. (1998). Biological monitoring of environmental pollution and human exposure to metals in Tarragona, Spain. I. Levels in hair of school children. Trace Elements and Electrocytes, 15, 39-43.

***Greater Vancouver Regional District. (2007). Energy from Waste Fact Sheet. Vancouver, British Columbia, Canada, Greater Vancouver Regional District.
Ref Type: Generic***

Hippelein, M., Kaupp, H., Doerr, G., McLachlan, M., & Hutzinger, O. (1996a). Baseline contamination assessment for a new resource recovery facility in Germany Part II: Atmospheric concentrations of PCDD/F. *Chemosphere, 32,* 1605-1616.

Hippelein, M., Kaupp, H., Dorr, G., & Hutzinger, O. (1996b). Baseline contamination assessment for a new resource recovery facility in Germany: Part III: PCDD/Fs, HCB, and PCBs in cow's milk. *Chemosphere, 32,* 1617-1622.

Jimenez, B., Eljarrat, E., Hernandez, L. M., Rivera, J., & Gonzalez, M. J. (1996). Polychlorinated dibenzo-p-dioxins and dibenzofurans in soils near a clinical waste incinerator in Madrid, Spain. Chemometric comparison with other pollution sources and soils. Chemosphere, 32, 1327-1348.

Keller, T., Matyssek, R., & Gunthardt-Goerg, M. S. (1994). Beech foliage as a bioindicator of pollution near a waste incinerator. Environmental Pollution, 85, 185-189.

Kinnes, G. M. & Bryant, C. J. (1992). Health Hazard Evaluation Report No. HETA-88-207-2195, Northwest Incinerator, Philadelphia, Pennsylvania. Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-88.-207.-2195., 28.pages., 38.references., %1992..

Kinnes, G. M., Hanley, K. W., & Krake, A. M. (1995). Health Hazard Evaluation Report No. HETA-90-0329-2482, New York City Department of Sanitation, New York, New York. Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-90.-0329.-2482., 54 pages., 64 references., %1995..

Koblantz, S. M., Teiger, D. G., Kitto, M. E., Dutkiewicz, V. A., Matuszek, J. M., & Husain, L. (1997). Impact assessment of emissions from a municipal waste incinerator. Environmental Monitoring and Assessment, 45, 21-42.

Kumagai, S., Koda, S., Miyakita, T., & Ueno, M. (2002). Polychlorinated dibenzo-p-dioxin and dibenzofuran concentrations in serum samples of workers at intermittently burning municipal waste incinerators in Japan. Occupational and Environmental Medicine, 59, 362-368.

Kumagai, S., Koda, S., Miyakita, T., Yamaguchi, H., Katagi, K., & Yasuda, N. (2000). Polychlorinated dibenzo-p-dioxin and dibenzofuran concentrations in the serum samples of workers at continuously burning municipal waste incinerators in Japan. Occupational and Environmental Medicine, 57, 204-210.

Kurttio, P., Pekkanen, J., Alfthan, G., Paunio, M., Jaakkola, J. J., & Heinonen, O. P. (1998). Increased mercury exposure in inhabitants living in the vicinity of a hazardous waste incinerator: a 10-year follow-up. Arch.Environ.Health, 53, 129-137.

Lee, C. C., Chen, H. L., Su, H. J., Guo, Y. L., & Liao, P. C. (2005). Evaluation of PCDD/Fs patterns emitted from incinerator via direct ambient sampling and indirect serum levels assessment of Taiwanese. Chemosphere, 59, 1465-1474.

Lee, S. J., Ikonomou, M. G., Park, H., Baek, S. Y., & Chang, Y. S. (2007). Polybrominated diphenyl ethers in blood from Korean incinerator workers and general population. Chemosphere, 67, 489-497.

Leem, J. H., Lee, D. S., & Kim, J. (2006). Risk factors affecting blood PCDDs and PCDFs in residents living near an industrial incinerator in Korea. Arch.Environ.Contam Toxicol., 51, 478-484.

Liem, A. K. D., Hoogerbrugge, R., Kootstra, P. R., van, d., V, & De Jong, A. P. J. M. (1991). Occurrence of dioxins in cow's milk in the vicinity of municipal waste incinerators and a metal reclamation plant in the Netherlands. Chemosphere, 23, 1675-1684.

Llobet, J. M., Granero, S., Torres, A., Schuhmacher, M., & Domingo, J. L. (1998). Biological monitoring of environmental pollution and human exposure to metals in Tarragona, Spain. III. Blood levels. Trace Elements and Electrocytes, 15, 76-80.

Llobet, J. M., Schuhmacher, M., & Domingo, J. L. (2000). Observations on metal trends in soil and vegetation samples collected in the vicinity of a hazardous waste incinerator under construction (1996-1998). *Toxicological and Environmental Chemistry, 77,* 119-129.

Loppi, S., Putorti, E., Pirintsos, S. A., & De, D., V (2000). Accumulation of heavy metals in epiphytic lichens near a municipal solid waste incinerator (central Italy). Environmental Monitoring and Assessment, 61, 361-371.

Lorber, M., Pinsky, P., Gehring, P., Braverman, C., Winters, D., & Sovocool, W. (1998). Relationships between dioxins in soil, air, ash, and emissions from a municipal solid waste incinerator emitting large amounts of dioxins. Chemosphere, 37, 2173-2197.

Lovett, A. A., Foxall, C. D., Creaser, C. S., & Chewe, D. (1997). PCB and PCDD/DF congeners in locally grown fruit and vegetable samples in Wales and England. Chemosphere, 34, 1421-1436.

Lovett, A. A., Foxall, C. D., Creaser, C. S., & Chewe, D. (1998). PCB and PCDD/DF concentrations in egg and poultry meat samples from known urban and rural locations in Wales and England. Chemosphere, 37, 1671-1685.

Mari, M., Borrajo, M. A., Schuhmacher, M., & Domingo, J. L. (2007). Monitoring PCDD/Fs and other organic substances in workers of a hazardous waste incinerator: a case study. Chemosphere, 67, 574-581.

Mari, M., Nadal, M., Schuhmacher, M., & Domingo, J. L. (2008a). Monitoring PCDD/Fs, PCBs and metals in the ambient air of an industrial area of Catalonia, Spain. Chemosphere.

Mari, M., Schuhmacher, M., & Domingo, J. L. (2008b). Levels of metals and organic substances in workers at a hazardous waste incinerator: a follow-up study. Int.Arch.Occup.Environ.Health.

Mari, M., Schuhmacher, M., Feliubadalo, J., & Domingo, J. L. (2008c). Air concentrations of PCDD/Fs, PCBs and PCNs using active and passive air samplers. Chemosphere, 70, 1637-1643.

Mateu, J., Bauza De, M. I. R. A., Forteza, R., Cerda, V., Colom, M., & Oms, M. (1999). Heavy metals in the aerosols collected at two stations in Mallorca (Spain). *Water Air and Soil Pollution, 112,* 349-363.

Misik, M., Micieta, K., Solenska, M., Misikova, K., Pisarcikova, H., & Knasmuller, S. (2007). In situ biomonitoring of the genotoxic effects of mixed industrial emissions using the Tradescantia micronucleus and pollen abortion tests with wild life plants: demonstration of the efficacy of emission controls in an eastern European city. Environ.Pollut., 145, 459-466.

Mukerjee, S., Somerville, M. C., Willis, R. D., Fox, D. L., Stevens, R. K., Kellogg, R. B. et al. (1996). Integrated assessment of reduced emission impacts from a biomedical waste incinerator. Atmospheric characterization and modeling applications on particulate matter and acid gases. Environmental Science and Technology, 30, 1680-1686.

Nadal, M., Bocio, A., Schuhmacher, M., & Domingo, J. L. (2005a). Monitoring metals in the population living in the vicinity of a hazardous waste incinerator: levels in hair of school children. Biological Trace Element Research, 104, 203-213.

Nadal, M., Bocio, A., Schuhmacher, M., & Domingo, J. L. (2005b). Trends in the levels of metals in soils and vegetation samples collected near a hazardous waste incinerator. Arch.Environ.Contam Toxicol., 49, 290-298.

Nadal, M., Perello, G., Schuhmacher, M., Cid, J., & Domingo, J. L. (2008). Concentrations of PCDD/PCDFs in plasma of subjects living in the vicinity of a hazardous waste incinerator: Follow-up and modeling validation. Chemosphere.

Oh, J. E., Choi, S. D., Lee, S. J., & Chang, Y. S. (2006). Influence of a municipal solid waste incinerator on ambient air and soil PCDD/Fs levels. Chemosphere, 64, 579-587.

Ohsaki, Y., Matsueda, T., & Ohno, K. (1995). Levels and source of non-ortho coplanar polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and polychlorinated dibbenzofurans in pond sediments and paddy field soil. Water Research, 29, 1379-1385.

Olie K., Addink R., Schoonenbroom M. Metals as Catalysts during the formation and decomposition of chlorinated dioxins and furans in incineration processes. *Journal of the Air and Waste Management Association.* 1998, 48:101-105.

Olie K., Vermeulen P. L. and Hutzinger O. Chlorodibenzo-p-dioxins and Chloro - dibenzofurans are Trace Components of Fly Ash and Flue Gas of Some Municipal Incinerators in the Netherlands. *Chemosphere*. 1977, 6:455-459.

Otani, T., Seike, N., & Miwa, T. (2006). Levels of dioxins in rice, wheat, soybean, and adzuki bean cultivated in 1999 to 2002 in Japan and estimation of their intake. Shokuhin Eiseigaku Zasshi, 47, 182-188.

Park, S., Kim, S. J., Kim, K. S., Lee, D. S., & Kim, J. G. (2004). Influence of an industrial waste incinerator as assessed by the levels and congener patterns of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans. Environ.Sci.Technol., 38, 3820-3826.

Pollutech Geoenvironmental Limited. (2008). Surficial Soil Samping and Testing as per the MOE Certificate of Approval (Air) Requirements Algonquin Power Energy From Waste Inc, Brampton, Ontario. Prepared for Algonquin Power Energy From Waste Inc, Brampton, Ontario.

Poon, C., Gregory-Eaves, I., Connell, L. A., Guillore, G., Mayer, P. M., Ridal, J. et al. (2005). Air-vegetation partitioning of polychlorinated biphenyls near a point source. Environ.Toxicol.Chem., 24, 3153-3158.

Rahkonen, P. (1992). Airborne contaminants at waste treatment plants. Waste Manage.Res., 10, 411-421.

Ramos, L., Eljarrat, E., Hernandez, L. M., Alonso, L., Rivera, J., & Gonzalez, M. J. (1997). Levels of PCDDs and PCDFs in farm cow's milk located near potential contaminant sources in Asturias (Spain). Comparison with levels found in control, rural farms and commercial pasteurized cow's milks. Chemosphere, 35, 2167-2179.

Reis, M. F. (2007). The Portugese experience on environmental health surveillance related to USW incineration. In Workshop on "urban solid waste incinerator plants: technical aspects and health impacts".

Reis, M. F., Miguel, J. P., Sampaio, C., Aguiar, P., Melim, J. M., & Papke, O. (2007a). Determinants of dioxins and furans in blood of non-occupationally exposed populations living near Portuguese solid waste incinerators. Chemosphere, 67, S224-S230.

Reis, M. F., Sampaio, C., Aguiar, P., Mauricio, M. J., Pereira, M. J., & Papke, O. (2007b). Biomonitoring of PCDD/Fs in populations living near portuguese solid waste incinerators: levels in human milk. Chemosphere, 67, S231-S237.

Reis, M. F., Sampaio, C., Brantes, A., Aniceto, P., Melim, M., Cardoso, L. et al. (2007c). Human exposure to heavy metals in the vicinity of Portuguese solid waste incinerators--Part 1: biomonitoring of Pb, Cd and Hg in blood of the general population. Int.J.Hyg.Environ.Health, 210, 439-446.

Reis, M. F., Sampaio, C., Brantes, A., Aniceto, P., Melim, M., Cardoso, L. et al. (2007d). Human exposure to heavy metals in the vicinity of Portuguese solid waste incinerators--Part 3: biomonitoring of Pb in blood of children under the age of 6 years. Int.J.Hyg.Environ.Health, 210, 455-459.

Reis, M. F., Sampaio, C., Brantes, A., Aniceto, P., Melim, M., Cardoso, L. et al. (2007e). Human exposure to heavy metals in the vicinity of Portuguese solid waste incinerators--Part 2: biomonitoring of lead in maternal and umbilical cord blood. Int.J.Hyg.Environ.Health, 210, 447-454.

Reis, M. F., Segurado, S., Brantes, A., Simoes, H. T., Melim, J. M., Geraldes, V. et al. (2008). Ethics issues experienced in HBM within Portuguese health surveillance and research projects. Environ.Health, 7 Suppl 1, S5.

Rimmer, D. L., Vizard, C. G., Pless-Mulloli, T., Singleton, I., Air, V. S., & Keatinge, Z. A. (2006). Metal contamination of urban soils in the vicinity of a municipal waste incinerator: one source among many. Sci.Total Environ., 356, 207-216.

Rodrigues, J. P., Nascimento, A., Penha, A., Vidal, D., Torres, A., & Correia, V. (2003). Report: Valorsul integrated waste management: waste incineration plant. Waste Manag.Res., 21, 74-80.

Roth, A. J. & Riggs, K. B. (1998). Ambient air PCDD/PCDF concentrations in Montgomery County, Ohio. Environmental Engineering Science, 15, 181-189.

Rumbold, D., Bruner, M., Mihalik, M., & Marti, E. (1997). Biomonitoring environmental contaminants near a municipal solid-waste combustor. Environmental Pollution, 96, 99-105.

Schecter, A., Papke, O., Ball, M., Lis, A., & Brandt-Rauf, P. (1995). Dioxin concentrations in the blood of workers at municipal waste incinerators. Occupational and Environmental Medicine, 52, 385-387.

Schoeters, G. (2007a). Next steps in the human biomonitoring project Belgium: VITO.

Schoeters, G. (2007b). The Flemish Human Biomonitoring Program: The causal chain from exposure to effects Belgium: VITO.

Schroijen, C., Baeyens, W., Schoeters, G., Den, H. E., Koppen, G., Bruckers, L. et al. (2008). Internal exposure to pollutants measured in blood and urine of Flemish adolescents in function of area of residence. Chemosphere, 71, 1317-1325.

Schuhmacher, M., Granero, S., Llobet, J. M., de Kok, H. A., & Domingo, J. L. (1997). Assessment of baseline levels of PCDD/F in soils in the neighbourhood of a new hazardous waste incinerator in Catalonia, Spain. Chemosphere, 35, 1947-1958.

Schuhmacher, M., Domingo, J. L., Llobet, J. M., Mueller, L., Suenderhauf, W., & Jager, J. (1998). Baseline levels of PCDDs in vegetation samples collected in the vicinity of a new hazardous waste incinerator in Catalonia, Spain. Chemosphere, 36, 2581-2591.

Schuhmacher, M., Agramunt, M. C., Rodriguez-Larena, M. C., az-Ferrero, J., & Domingo, J. L. (2002). Baseline levels of PCDD/Fs in soil and herbage samples collected in the vicinity of a new hazardous waste incinerator in Catalonia, Spain. *Chemosphere, 46,* 1343-1350.

Schuhmacher, M., Domingo, J. L., Agramunt, M. C., Bocio, A., & Muller, L. (2002a). Biological monitoring of metals and organic substances in hazardous-waste incineration workers. Int.Arch.Occup.Environ.Health, 75, 500-506.

Schuhmacher, M., Domingo, J. L., Hagberg, J., & Lindstrom, G. (2004a). PCDD/F and non-ortho PCB concentrations in adipose tissue of individuals living in the vicinity of a hazardous waste incinerator. Chemosphere, 57, 357-364.

Schuhmacher, M., Domingo, J. L., Kiviranta, H., & Vartiainen, T. (2004b). Monitoring dioxins and furans in a population living near a hazardous waste incinerator: levels in breast milk. Chemosphere, 57, 43-49.

Schuhmacher, M., Domingo, J. L., Llobet, J. M., Kiviranta, H., & Vartiainen, T. (1999a). PCDD/F concentrations in milk of nonoccupationally exposed women living in southern Catalonia, Spain. Chemosphere, 38, 995-1004.

Schuhmacher, M., Domingo, J. L., Llobet, J. M., Lindstrom, G., & Wingfors, H. (1999b). Dioxin and dibenzofuran concentrations in blood of a general population from Tarragona, Spain. Chemosphere, 38, 1123-1133.

Schuhmacher, M., Granero, S., Xifro, A., Domingo, J. L., Rivera, J., & Eljarrat, E. (1998). Levels of PCDD/Fs in soil samples in the vicinity of a municipal solid waste incinerator. Chemosphere, 37, 2127-2137.

Schuhmacher, M., Kiviranta, H., Vartiainen, T., & Domingo, J. L. (2007). Concentrations of polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) in milk of women from Catalonia, Spain. Chemosphere, 67, S295-S300.

Schuhmacher, M., Rodriguez-Larena, M. C., Agramunt, M. C., az-Ferrero, J., & Domingo, J. L. (2002b). Environmental impact of a new hazardous waste incinerator in Catalonia, Spain: PCDD/PCDF levels in herbage samples. Chemosphere, 48, 187-193.

Segura-Munoz, S. I., Bocio, A., Trevilato, T. M., Takayanagui, A. M., & Domingo, J. L. (2004). Metal concentrations in soil in the vicinity of a municipal solid waste landfill with a deactivated medical waste incineration plant, Ribeirao Preto, Brazil. Bull.Environ.Contam Toxicol., 73, 575-582.

Seike, N., Miwa, T., Otani, T., & Ueji, M. (2005). Levels of dioxins in Japanese fruit in 1999 to 2002 and estimation of their intake. Shokuhin Eiseigaku Zasshi, 46, 256-262.

Shih, T. S., Chen, H. L., Wu, Y. L., Lin, Y. C., & Lee, C. C. (2006). Exposure assessment of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) in temporary municipal-waste-incinerator maintenance workers before and after annual maintenance. Chemosphere, 64, 1444-1449.

Sonich-Mullin, C. (1991). Feasibility of Environmental Monitoring and Exposure Assessment for a Municipal Waste Combustor: Rutland, Vermont Pilot Study. Govt.Reports Announcements.& Index.(GRA.&I), Issue.15., %2091.

Stenhouse, I. A. & Badsha, K. S. (1990). PCB, PCDD and PCDF concentrations in soils from the Kirk Sandall/ Edenthorpe/ Barnby Dun Area (England, UK). Chemosphere, 21, 563-574.

Tajimi, M., Uehara, R., Watanabe, M., Oki, I., Ojima, T., & Nakamura, Y. (2005). Correlation coefficients between the dioxin levels in mother's milk and the distances to the nearest waste incinerator which was the largest source of dioxins from each mother's place of residence in Tokyo, Japan. Chemosphere, 61, 1256-1262.

Tharr, D. (1991). Workplace Exposures at a Waste-to-Energy Facility. Applied Occupational and Environmental Hygiene, 6, 573-574.

Tries, M. A., Ring, J. P., & Chabot, G. E. (1996). Environmental monitoring for a low-level radioactive waste management facility: incinerator operations. Health Phys., 71, 384-394.

Willis, B. C., Howie, M. M., & Williams, R. C. (2002). Agency for Toxic Substances and Disease Registry: A Guidance Manual for Public Health Assessors. Atlanta, GA, US Department of Health and Human Services.
Ref Type: Generic

Wood Buffalo Environmental Association (2007). Human Exposure Monitoring Program: 2006 Monitoring Year Alberta, Canada: Wood Buffalo Environmental Association.

Yan, J. H., Xu, M. X., Lu, S. Y., Li, X. D., Chen, T., Ni, M. J. et al. (2008). PCDD/F concentrations of agricultural soil in the vicinity of fluidized bed incinerators of co-firing MSW with coal in Hangzhou, China. J.Hazard.Mater., 151, 522-530.

Additional References:

Agency for Toxic Substances and Disease Registry (ATSDR). 1996. Guidance for ATSDR Health Studies.

Angerer, J. et al. 2007. Human Biomonitoring: State of the Art. *International Journal of Hygiene and Environmental Health,* **210,** 201-228.

CCME (Canadian Council for the Ministers of the Environment). 2008. Air. URL: http://www.ccme.ca/ourwork/air.html

CEC (Commission of the European Communities). 2004. Volume II - Technical Annexes to the Communication of the Commission on the European Environment and Health Action Plan 2004-2010. COM(2004) 416 Final.

Cochrane Collaboration. 2008. Cochrane Handbook for Systematic Reviews of Interventions Version 5.0.0. Higgins JPT, Green S (editors). URL: http://www.cochrane-handbook.org/

CTQ Centre de Toxicologie du Quebec. 2006. Programme de comparaisons interlaboratoires pour les métaux en milieu biologique (PCI). URL: http://www.inspq.qc.ca/ctq/paqe/pcimmb/default.asp?Page=2b&Lg=fr&paqe=1

ESBIO (Expert Team to Support Biomonitoring in Europe). 2007. Development of a Coherent Approach to Human Biomonitoring in Europe – Publishable Final Activity Report.

European Commission. 2007. Work Programme 2007 – Cooperation – Theme 6 – Environment (including Climate Change).

European Human Biomonitoring. 2005. List of Governmental Representatives. URL: http://www.eu-humanbiomonitoring.org/doc/list_political_0505.doc

European Human Biomonitoring. 2008. Members of the Group. URL: http://www.eu-humanbiomonitoring.org/sub/implgroup/members.htm

Health Canada. 2007a. Human Biomonitoring of Environmental Chemicals. URL: http://www.hc-sc.gc.ca/ewh-semt/contaminants/biomonitoring-biosurveillance-eng.php

Health Canada. 2007b. Biomonitoring of Environmental Chemicals in the Canadian Health Measures Survey. URL: http://www.hc-sc.gc.ca/ewh-semt/contaminants/health-measures-sante-eng.php

Health Canada. 2007c. Maternal-Infant Research on Environmental Chemicals (The MIREC Study). URL: http://www.hc-sc.gc.ca/ewh-semt/contaminants/mirec/index-eng.php

Hong Kong Environmental Protection Department: Air Policy Group. 2008. Guidance note of the best practicable means for incinerators: municipal waste incinerators. BPM 12/1 (08).

Jacques Whitford. 2008. Draft Interim Report on Ambient Air Monitoring at the Courtice Road Site. October 1, 2008.

Kapral, M.K., Wang, H., Mamdani, M., Tu, J.V., 2002. Effect of Socioeconomic Status on Treatment and Mortality After Stroke. *Stroke.* **33,** 268.

Keune H, Morrens B, Loots I. 2008. Risk communication and human biomonitoring: which practical lessons from the Belgian experience are of use for the EU perspective? *Environmental Health*. **7,** S11.

Last, J.M, ed. 2000. A Dictionary of Epidemiology, 4th Edition. Oxford University Press: USA, p.117.

Lorber M, Wang V, Walker Y, Gillooly. 2002. Impacts of dioxin emissions from the Shinkampo incinerator to the United States naval air facility at Atsugi, Japan. Part 1: Soil Impacts. *Organohalogen Compounds*. **57**, 289-292.

National Research Council (NRC). 2000. Waste Incineration and Public Health. National Academy Press: Washington, DC, pp112-181.

NHANES. 2007. Data Accomplishments. URL: http://www.cdc.gov/nchs/about/major/nhanes/DataAccomp.htm

Official Journal of the European Communities. 2000. Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste.

Ontario Ministry of the Environment. 2004. Guideline A-7: Combustion and air pollution control requirements for new municipal waste incinerators. *Environmental Protection Act*, Part V, Section 27, and Part II, Section 9.

Region of Peel. 2008. Algonquin Power Energy From Waste Facility Liaison Committee. URL: http://www.region.peel.on.ca/pw/waste/facilities/algonquin-committee.htm

Reis, M.F. et al. 2008. Ethics Issues Experienced in HBM within Portuguese Health Surveillance and Research Projects. *Environmental Health*, **7 (Suppl 1): S5.**

Rothman, K.J. and S. Greenland. 1998. Modern Epidemiology, 2nd Edition. Lippincott Williams & Wilkins, p435.

Smith, L. 2007. Energy from Waste Facility in the Region of Durham. URL: http://www.region.durham.on.ca/departments/health/pub/energyFromWasteReport.pdf

Taiwan Environmental Protection Administration. 2006. Waste incinerator air pollutant emissions standards.

Taiwan Environmental Protection Administration. 2003. Waste incinerator dioxin control and emission standards.

United Nations Food and Agriculture Organization (UN FAO). 1990. Watershed Management Field Manual.

United States Federal Register. 1995. Standards of performance for new stationary sources and emission guidelines for existing sources/municipal waste combustors. Vol. 60, No.243-65387.

United States Federal Register. 2006. Standards of performance for new stationary sources and emission guidelines for existing sources/large municipal waste combustors-Final Rule. Vol. 71, No.90-27324.

World Health Organization. World Health Survey. Web site accessed October 1, 2008. http://www.who.int/healthinfo/survey/en/index.html

Walker Y, Lorber M, Wang V, Gillooly. 2002. Impacts of dioxin emissions from the Shinkampo incinerator to the United States naval air facility at Atsugi, Japan. Part 2: Air Impacts. *Organohalogen Compounds*. **56,** 481-484.

APPENDIX A

Scientific Literature Search Strategy

The following are the search strategies that were used in the Systematic Literature Review. The descriptors (also called subject headings or controlled terminology) and syntax were tailored to meet the demands of the particular database in use, as each database is unique in the descriptors and syntax required. For example, when searching PubMed or MEDLINE, Medical Subject Heading (MeSH) descriptors were used, as this is the terminology required to search this database. An example of this would be the use of the general "Environmental Pollutants" MeSH descriptor in place of specifying all potential environmental pollutants.

The final search set will provide the final set of results which will be subjected to the inclusion/exclusion criteria. It should be noted that all exclusion criteria (i.e. with the exception of limiting the publication date from 1990-present) will be applied after-the-fact by the reviewers, and will not be integrated into the search.

Some specifications have been omitted based on the strategy of the search. For example, there is no need to search for different types of incinerators (i.e. municipal waste incinerator, hazardous waste incinerator, etc.). Simply searching for keyword *incinerat** should bring forward all such articles as incinerator is always used to qualify the facility regardless of the type of waste burnt.

OVID DATABASE

Medline In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) <1950 to Present>

Limits: 1990-present

1. Pollutant Exposure

exp Environmental Exposure/
exp Environmental Pollutants/ OR Environmental Pollution.sh. OR exp Air Pollution/ OR exp Water Pollution/
Metals, Heavy.sh.

AND

2. Incineration

Incineration.sh.
Refuse Disposal.sh. (1990-1993)

AND

3. Type of Measurement (or Study)

ae.fs.
exp Cohort Studies/
Epidemiologic Methods.sh.
ep.fs.
exp Body Burden/
Environmental Monitoring.sh.
Data Collection.sh. OR Health Surveys.sh. OR exp Population Surveillance/ OR Questionnaires.sh.

Search run 1Oct2008

1 exp Environmental Exposure/ (144426)

2 exp Environmental Pollutants/ or Environmental Pollution.sh. or exp Air Pollution/ or exp Water Pollution/ (304901)

3 Metals, Heavy.sh. (8165)

4 (exposur$ or exposed).ti,ab. (949765)

5 (((air or environmental or soil or water) adj (pollutant$ or pollution)) or air quality or gas$ emission?).ti,ab. (38477)

6 (benzofuran? or dioxin? or polychlorodibenzo-4-dioxin? or polychlorinated dibenzodioxin? or polychlorinated dibenzofuran? or PCDD? or dibenzofuran? or tetrachlorodibenzo-p-dioxin? or tetrachlorodibenzodioxin? or TCDD? or furan? or hexachlorobenzene? or polychlorinated biphenyl? or PAH? or polycyclic aromatic hydrocarbon? or volatile organic compound? or heavy metal? or lead or chromium or cadmium or mercury).mp. (673533)

7 (Environmental Exposure or Occupational Exposure or Population Exposure).sh. (135209)

8 (Air Pollution or Soil Pollution).sh. or exp Water Pollution/ or Pollutant.sh. or Air Pollutant.sh. or Gas Waste.sh. or Soil Pollutant.sh. (118705)

9 or/1-6 (1773312)

10 or/4-8 (1667502)
11 Incineration.sh. (5799)
12 Refuse Disposal.sh. (7770)
13 limit 12 to yr="1990 - 1993" (770)
14 (energy from waste or EFW or incinerat$ or thermal destruction or thermal treatment$).ti,ab. (9619)
15 Incineration.sh. (5799)
16 or/11,13-14 (12128)
17 or/14-15 (11442)
18 ae.fs. (1530999)
19 exp Cohort Studies/ (749194)
20 Epidemiologic Methods.sh. (23273)
21 ep.fs. (1203093)
22 exp Body Burden/ (16125)
23 Environmental Monitoring.sh. (52533)
24 (Data Collection or Health Surveys).sh. or exp Population Surveillance/ or Questionnaires.sh. (355587)
25 ((adverse adj2 effect$) or adverse$ affect$).ti,ab. (165040)
26 cohort$.ti,ab. (252240)
27 (prospective adj (study or studies or trial or trials)).ti,ab. (159570)
28 (longitudinal adj (study or studies or trial or trials)).ti,ab. (48469)
29 ((follow up or followup) adj (study or studies or trial or trials)).ti,ab. (49448)
30 (epidemiologic$ adj (method$ or study or studies)).ti,ab. (77083)
31 (biosurveillance or bio-surveillance or surveillance).ti,ab. (109277)
32 body burden.ti,ab. (2897)
33 (health adj (effect$ or hazard$ or outcome$ or study or studies)).ti,ab. (51346)
34 (biomonitor$ or bio-monitor$ or measure$ or monitor$).mp. (3360912)
35 environmental impact.ti,ab. (3214)
36 (questionnaire$ or survey$).ti,ab. (678164)
37 exp Cohort Analysis/ or Follow Up.sh. or Longitudinal Study.sh. or Prospective Study.sh. (1069451)

38 Epidemiological Data.sh. (16621)
39 ep.fs. (1203093)
40 Body Burden.sh. (6490)
41 Health Hazard.sh. (20160)
42 (Air Monitoring or Biological Monitoring or Environmental Monitoring or Pollution Monitoring).sh. (67231)
43 (Environmental Impact or Environmental Impact Assessment).sh. (11284)
44 Health Survey.sh. or exp Questionnaire/ or Population Risk.sh. or Population Research.sh. (397033)
45 (Controlled Study or Major Clinical Study).sh. (3223217)
46 or/19-36 (5659857)
47 or/25-45 (7927844)
48 46 and 16 and 9 (2808)
49 limit 48 to yr="1990 - 2009" (2674)
50 10 and 17 and 47 (2592)
51 limit 50 to yr="1990 - 2009" (2473)
52 from 49 keep 1-1403 (1403)
53 from 51 keep 1087-2473 (1387)

PubMed DATABASE

Limits: 1990-present

1. Pollutant Exposure
Environmental Exposure[mh]
Environmental Pollutants[mh] OR Environmental Pollution[mh:noexp] OR Air Pollution[mh] OR Water Pollution[mh]
Metals, Heavy[mh:noexp]
exposur*[tiab] OR exposed[tiab]
air pollutant*[tiab] OR environmental pollutant*[tiab] OR soil pollutant*[tiab] OR water pollutant*[tiab] OR air pollution[tiab] OR environmental pollution[tiab] OR soil pollution[tiab] OR water pollution[tiab] OR air quality[tiab] OR gas* emission*[tiab]
benzofuran*[all fields] OR dioxin*[all fields] OR polychlorodibenzo-4-dioxin*[all fields] OR polychlorinated dibenzodioxin*[all fields] OR polychlorinated dibenzofuran*[all fields] OR PCDD*[all fields] OR dibenzofuran*[all fields] OR tetrachlorodibenzo-p-dioxin*[all fields] OR tetrachlorodibenzodioxin*[all fields] OR TCDD*[all fields] OR furan*[all fields] OR hexachlorobenzene[all fields] OR polychlorinated biphenyl*[all fields] OR PAH*[all fields] OR polycyclic aromatic hydrocarbon*[all fields] OR volatile organic compound*[all fields] OR heavy metal*[all fields] OR lead[all fields] OR chromium[all fields] OR cadmium[all fields] OR mercury[all fields]

AND

2. Incineration
Incineration[mh]
Refuse Disposal[mh:noexp] (1990-1993)
energy from waste[tiab] OR EFW[tiab] OR incinerat*[tiab] OR thermal destruction[tiab] OR thermal treatment*[tiab]

AND

3. Type of Measurement (or Study)
adverse effects[MeSH subheading]
Cohort Studies[mh]
Epidemiologic Methods[mh:noexp]
epidemiology[MeSH subheading]
Body Burden[mh]
Environmental Monitoring[mh:noexp]
Data Collection[mh:noexp] OR Health Surveys[mh:noexp] OR Population Surveillance[mh] OR Questionnaires[mh:noexp]
adverse effect*[tiab] OR adverse* affect*[tiab]
cohort*[tiab] OR prospective study[tiab] OR prospective studies[tiab] OR prospective trial*[tiab] OR longitudinal study[tiab] OR longitudinal studies[tiab] OR longitudinal trial*[tiab]
follow up study[tiab] OR follow up studies[tiab] OR follow up trial*[tiab] OR followup study[tiab] OR followup studies[tiab] OR followup trial*[tiab]
epidemiologic* method*[tiab] OR epidemiologic* study[tiab] OR epidemiologic* studies[tiab]
biosurveillance[tiab] OR bio-surveillance[tiab] OR surveillance[tiab] OR body burden[tiab]
health effect*[tiab] OR health hazard*[tiab] OR health outcome*[tiab] OR health study[tiab] OR health studies[tiab]
biomonitor*[all fields] OR bio-monitor*[all fields] OR measure*[all fields] OR monitor*[all fields] OR environmental impact[tiab] OR questionnaire*[tiab] OR survey*[tiab]
AND
in process[sb] OR publisher[sb] OR pubmednotmedline[sb]
Search run 1Oct2008

#28	Search #26 AND #27	17:25:09	50

#27	Search in process[sb] OR publisher[sb] OR pubmednotmedline[sb]	17:24:41	1021967
#26	Search **(#1 OR #2 OR #3 OR #4 OR #5 OR #6) AND (#8 OR #9 OR #10) AND (#11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24)** Limits: **Entrez Date from 1990 to 2009**	17:22:56	1521
#25	Search **(#1 OR #2 OR #3 OR #4 OR #5 OR #6) AND (#8 OR #9 OR #10) AND (#11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24)**	17:22:17	1588
#24	Search **biomonitor*[all fields] OR bio-monitor*[all fields] OR measure*[all fields] OR monitor*[all fields] OR environmental impact[tiab] OR questionnaire*[tiab] OR survey*[tiab]**	17:17:54	2193460
#23	Search **health effect*[tiab] OR health hazard*[tiab] OR health outcome*[tiab] OR health study[tiab] OR health studies[tiab]**	17:17:19	27312
#22	Search **biosurveillance[tiab] OR bio-surveillance[tiab] OR surveillance[tiab] OR body burden[tiab]**	17:17:02	62330
#21	Search **epidemiologic* method*[tiab] OR epidemiologic* study[tiab] OR epidemiologic* studies[tiab]**	17:16:32	50857
#20	Search **follow up study[tiab] OR follow up studies[tiab] OR follow up trial*[tiab] OR followup study[tiab] OR followup studies[tiab] OR followup trial*[tiab]**	17:16:17	29873
#19	Search **cohort*[tiab] OR prospective study[tiab] OR prospective studies[tiab] OR prospective trial*[tiab] OR longitudinal study[tiab] OR longitudinal studies[tiab] OR longitudinal trial*[tiab]**	17:15:46	231079
#18	Search **adverse effect*[tiab] OR adverse* affect*[tiab]**	17:15:17	64933
#17	Search **Data Collection[mh:noexp] OR Health Surveys[mh:noexp] OR Population Surveillance[mh] OR Questionnaires[mh:noexp]**	17:15:02	282968
#16	Search **Environmental Monitoring[mh:noexp]**	17:14:51	36742
#15	Search **Body Burden[mh]**	17:14:43	13490
#14	Search **epidemiology[MeSH subheading]**	17:14:34	1063604
#13	Search **Epidemiologic Methods[mh:noexp]**	17:14:25	22435
#12	Search **Cohort Studies[mh]**	17:14:14	669526
#11	Search **adverse effects[MeSH subheading]**	17:14:03	1293934
#10	Search **energy from waste[tiab] OR EFW[tiab] OR incinerat*[tiab] OR thermal destruction[tiab] OR thermal treatment*[tiab]**	17:13:22	4425
#9	Search **Refuse Disposal[mh:noexp]** Limits: **Publication Date from 1990 to 1993**	17:13:07	751
#8	Search **Incineration[mh]**	17:12:32	2198
#6	Search **benzofuran*[all fields] OR dioxin*[all fields] OR polychlorodibenzo-4-dioxin*[all fields] OR polychlorinated dibenzodioxin*[all fields] OR polychlorinated dibenzofuran*[all fields] OR PCDD*[all fields] OR dibenzofuran*[all fields] OR tetrachlorodibenzo-p-dioxin*[all fields] OR tetrachlorodibenzodioxin*[all fields] OR TCDD*[all fields] OR furan*[all fields] OR hexachlorobenzene[all fields] OR polychlorinated biphenyl*[all fields] OR PAH*[all fields] OR polycyclic aromatic hydrocarbon*[all fields] OR volatile organic compound*[all fields] OR heavy metal*[all fields] OR lead[all fields] OR chromium[all fields] OR cadmium[all fields] OR mercury[all fields]**	17:11:35	378666
#5	Search **air pollutant*[tiab] OR environmental pollutant*[tiab] OR soil pollutant*[tiab] OR water pollutant*[tiab] OR air pollution[tiab] OR environmental pollution[tiab] OR soil pollution[tiab] OR water pollution[tiab] OR air quality[tiab] OR gas* emission*[tiab]**	17:10:19	5410
#4	Search **exposur*[tiab] OR exposed[tiab]**	17:10:07	540251
#3	Search **Metals, Heavy[mh:noexp]**	17:09:55	8012
#2	Search **Environmental Pollutants[mh] OR Environmental Pollution[mh:noexp] OR Air Pollution[mh] OR Water Pollution[mh]**	17:09:45	140521
#1	Search **Environmental Exposure[mh]**	17:09:33	110630

Toxline DATABASE

Search run 1Oct2008
(exposure OR exposures OR exposed OR pollutant) AND ("energy from waste" OR EFW OR incinerat* OR "thermal destruction" OR "thermal treatment") AND ("adverse effect" OR "adverse affect" OR cohort OR prospective OR longitudinal OR "follow up" OR followup OR epidemiologic* OR biosurveillance OR bio-surveillance OR surveillance OR "body burden" OR "health effect" OR "health hazard" OR "health outcome" OR "health study" OR "health studies" OR biomonitor* OR bio-monitor* OR measure* OR monitor* OR "environmental impact" OR questionnaire OR survey)

=1623 results,1076 from 1990-present

<u>Cambridge Scientific's Environmental Science and Pollution Management</u> (via Scholar's Portal) **<u>DATABASE</u>**

1990-present

exposur* OR exposed
"air pollutant*" OR "environmental pollutant*" OR "soil pollutant*" OR "water pollutant*" OR "air pollution" OR "environmental pollution" OR "soil pollution" OR "water pollution" OR "air quality"
benzofuran* OR dioxin* OR polychlorodibenzo-4-dioxin* OR "polychlorinated dibenzodioxin*" OR "polychlorinated dibenzofuran*" OR PCDD* OR dibenzofuran* OR tetrachlorodibenzo-p-dioxin* OR tetrachlorodibenzodioxin* OR TCDD* OR furan* OR hexachlorobenzene OR "polychlorinated biphenyl*" OR PAH* OR "polycyclic aromatic hydrocarbon*" OR "volatile organic compound*" OR "heavy metal*" OR lead OR chromium OR cadmium OR mercury

AND

"energy from waste" OR EFW OR incinerat* OR "thermal destruction" OR "thermal treatment*"

AND

cohort* OR "prospective study" OR "prospective studies" OR "prospective trial*" OR "longitudinal study" OR "longitudinal studies" OR "longitudinal trial*" OR "follow up study" OR "follow up studies" OR "follow up trial*" OR "followup study" OR "followup studies" OR "followup trial*"
"adverse effect*" OR "adverse* affect*" OR "epidemiologic* method*" OR "epidemiologic* study" OR "epidemiologic* studies" OR biosurveillance OR "bio-surveillance" OR surveillance OR "body burden"
"health effect*" OR "health hazard*" OR "health outcome*" OR "health study" OR "health studies" OR biomonitor* OR "bio-monitor*" OR measure* OR monitor* OR "environmental impact" OR questionnaire* OR survey*

Search run 3Oct2008, =1039 results

The Cochrane Library (Wiley) 2008, Issue 3 DATABASE

Limits: 1990-present

1. Pollutant Exposure
Environmental Exposure[mh]
Environmental Pollutants[mh] OR Environmental Pollution[mh:noexp] OR Air Pollution[mh] OR Water Pollution[mh]
Metals, Heavy[mh:noexp]

exposur* OR exposed

air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*

benzofuran* OR dioxin* OR polychlorodibenzo-4-dioxin* OR polychlorinated dibenzodioxin* OR polychlorinated dibenzofuran* OR PCDD* OR dibenzofuran* OR tetrachlorodibenzo-p-dioxin*

tetrachlorodibenzodioxin* OR TCDD* OR furan* OR hexachlorobenzene OR polychlorinated biphenyl* OR PAH* OR polycyclic aromatic hydrocarbon* OR volatile organic compound* OR heavy metal* OR lead OR chromium OR cadmium OR mercury

AND

2. Incineration
Incineration[mh]
Refuse Disposal[mh:noexp] (1990-1993)

"energy from waste" OR EFW OR incinerat* OR "thermal destruction" OR "thermal treatment*"

Search run 1Oct2008 = 4 results in CENTRAL

Biosis Previews (Thompson), 1995-2008 DATABASE

Limits: 1995-present

1. Pollutant Exposure
MC=(exposur* OR exposed) OR DE=(exposur* OR exposed) OR TS=(exposur* OR exposed) OR TI=(exposur* OR exposed)

MC=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*) OR DE=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*)

TS=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*) OR TI=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*)

MC=(benzofuran* OR dioxin* OR polychlorodibenzo-4-dioxin* OR polychlorinated dibenzodioxin* OR polychlorinated dibenzofuran* OR PCDD* OR dibenzofuran* OR tetrachlorodibenzo-p-dioxin*) OR DE=(benzofuran* OR dioxin* OR polychlorodibenzo-4-dioxin* OR polychlorinated dibenzodioxin* OR polychlorinated dibenzofuran* OR PCDD* OR dibenzofuran* OR tetrachlorodibenzo-p-dioxin*)

TS=(benzofuran* OR dioxin* OR polychlorodibenzo-4-dioxin* OR polychlorinated dibenzodioxin* OR polychlorinated dibenzofuran* OR PCDD* OR dibenzofuran* OR tetrachlorodibenzo-p-dioxin*) OR TI=(benzofuran* OR dioxin* OR polychlorodibenzo-4-dioxin* OR polychlorinated dibenzodioxin* OR polychlorinated dibenzofuran* OR PCDD* OR dibenzofuran* OR tetrachlorodibenzo-p-dioxin*)

MC=(tetrachlorodibenzodioxin* OR TCDD* OR furan* OR hexachlorobenzene OR polychlorinated biphenyl* OR PAH* OR polycyclic aromatic hydrocarbon* OR volatile organic compound* OR heavy metal* OR lead OR chromium OR cadmium OR mercury) OR DE=(tetrachlorodibenzodioxin* OR TCDD* OR furan* OR hexachlorobenzene OR polychlorinated biphenyl* OR PAH* OR polycyclic aromatic hydrocarbon* OR volatile organic compound* OR heavy metal* OR lead OR chromium OR cadmium OR mercury)

TS=(tetrachlorodibenzodioxin* OR TCDD* OR furan* OR hexachlorobenzene OR polychlorinated biphenyl* OR PAH* OR polycyclic aromatic hydrocarbon* OR volatile organic compound* OR heavy metal* OR lead OR chromium OR cadmium OR mercury) OR TI=(tetrachlorodibenzodioxin* OR TCDD* OR furan* OR hexachlorobenzene OR polychlorinated biphenyl* OR PAH* OR polycyclic aromatic hydrocarbon* OR volatile organic compound* OR heavy metal* OR lead OR chromium OR cadmium OR mercury)

AND

2. Incineration
MC=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*) OR DE=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*) OR TS=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*) OR TI=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*)

AND

3. Type of Measurement (or Study)
MC=(adverse effect* OR adverse* affect*) OR DE=(adverse effect* OR adverse* affect*) OR TS=(adverse effect* OR adverse* affect*) OR TI=(adverse effect* OR adverse* affect*)

MC=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study) OR DE=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study) OR TS=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study) OR TI=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study)

MC=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*) OR DE=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*) OR TS=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*) OR TI=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*)

MC=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies) OR DE=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies) OR TS=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies) OR TI=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies)

MC=(biosurveillance OR bio-surveillance OR surveillance OR body burden) OR DE=(biosurveillance OR bio-surveillance OR surveillance OR body burden) OR TS=(biosurveillance OR bio-surveillance OR surveillance OR body burden) OR TI=(biosurveillance OR bio-surveillance OR surveillance OR body burden)

MC=(biomonitor* OR bio-monitor*) OR DE=(biomonitor* OR bio-monitor*) OR TS=(biomonitor* OR bio-monitor*) OR TI=(biomonitor* OR bio-monitor*)

Search run 1Oct2008

# 19	229	#18 OR #16 OR #15 OR #14 OR #13 OR #12 Databases=PREVIEWS Timespan=All Years
# 18	31	#17 AND #6 Databases=PREVIEWS Timespan=All Years
# 17	3,910	MC=(biomonitor* OR bio-monitor*) OR DE=(biomonitor* OR bio-monitor*) OR TS=(biomonitor* OR bio-monitor*) OR TI=(biomonitor* OR bio-monitor*) Databases=PREVIEWS Timespan=All Years
# 16	23	#11 AND #6 Databases=PREVIEWS Timespan=All Years
# 15	26	#10 AND #6 Databases=PREVIEWS Timespan=All Years
# 14	51	#9 AND #6 Databases=PREVIEWS Timespan=All Years
# 13	74	#8 AND #6 Databases=PREVIEWS Timespan=All Years
# 12	91	#7 AND #6 Databases=PREVIEWS Timespan=All Years
# 11	34,274	MC=(biosurveillance OR bio-surveillance OR surveillance OR body burden) OR DE=(biosurveillance OR bio-surveillance OR surveillance OR body burden) OR TS=(biosurveillance OR bio-surveillance OR surveillance OR body burden) OR TI=(biosurveillance OR bio-surveillance OR surveillance OR body burden) Databases=PREVIEWS Timespan=All Years
# 10	50,651	MC=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies) OR DE=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies) OR TS=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies) OR TI=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies) Databases=PREVIEWS Timespan=All Years

# 9	>100,000	MC=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*) OR DE=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*) OR TS=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*) OR TI=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*) Databases=PREVIEWS Timespan=All Years
# 8	>100,000	MC=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study) OR DE=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study) OR TS=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study) OR TI=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study) Databases=PREVIEWS Timespan=All Years
# 7	>100,000	MC=(adverse effect* OR adverse* affect*) OR DE=(adverse effect* OR adverse* affect*) OR TS=(adverse effect* OR adverse* affect*) OR TI=(adverse effect* OR adverse* affect*) Databases=PREVIEWS Timespan=All Years
# 6	5,039	#5 AND #4 Databases=PREVIEWS Timespan=All Years
# 5	15,075	MC=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*) OR DE=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*) OR TS=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*) OR TI=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*) Databases=PREVIEWS Timespan=All Years
# 4	>100,000	#3 OR #2 OR #1 Databases=PREVIEWS Timespan=All Years
# 3	>100,000	TS=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*) OR TI=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*) Databases=PREVIEWS Timespan=All Years
# 2	25,174	MC=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*) OR DE=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*) Databases=PREVIEWS Timespan=All Years
# 1	>100,000	MC=(exposur* OR exposed) OR DE=(exposur* OR exposed) OR TS=(exposur* OR exposed) OR TI=(exposur* OR exposed) Databases=PREVIEWS Timespan=All Years

APPENDIX B

External Contact Standard Emails and Questionnaires

Initial Form Email for Making External Contacts

SUBJECT: International Review of Environmental Surveillance Practices

Dear Mr./Mrs./Dr. [INSERT NAME HERE],

Jacques Whitford Limited, an internationally recognized environmental consulting firm, is conducting a review of international environmental surveillance practices in the energy-from-waste industry. This review, led by Dr. Christopher Ollson, has been initiated by the proposed construction of an energy-from-waste facility in the regions of Durham and York, Ontario, Canada.

As a component of the review, we have been asked to contact leaders in the field of environmental surveillance to obtain information on current surveillance activities and local regulations governing environmental surveillance in the energy-from-waste industry, if such activities/regulations exist at all. Environmental surveillance, by our working definition, can include but is not limited to activities surrounding the scope of environmental monitoring, human biomonitoring, health surveys and health studies.

As demonstrated by [INSERT EXPERIENCE HERE], we believe that you can be of great assistance in this review, and we would relish the opportunity to speak with you.

We would like to provide you with a brief questionnaire which outlines in detail the information we are seeking. You are not required to provide written answers to this questionnaire – it is merely an advanced notice of the scope of information we are seeking. We would like to follow up on this questionnaire with you in an over-the-phone interview, scheduled at a time that is convenient for you in consideration of the […] time zone difference. During the interview, your responses would be documented, and subsequently sent back to you to ensure that we have accurately captured the information you have provided.

If you feel that there is an individual who can add additional information to this process, please do not hesitate to forward this email to them such that we may establish contact with them. We thank you in advance for your time, and appreciate any assistance you could provide us in completing this review.

Sincerely,

[INSERT NAME HERE]

Study Team Member

Jacques Whitford Limited

Follow-Up Form Email for Making External Contacts

SUBJECT: Follow-Up - International Review of Environmental Surveillance Practices

Dear Mr./Mrs./Dr. [INSERT NAME HERE]

Further to our initial email, sent on [INSERT DATE HERE], we have identified you as an individual who may possess useful knowledge on the subject of environmental surveillance in the energy-from-waste industry or who may have contacts within the industry and government on the topic. Please find a copy of our initial email below which provides further details of the review.

We would like to provide you with a brief questionnaire which outlines in detail the information we are seeking. You are not required to provide written answers to this questionnaire – it is merely an advanced notice of the scope of information we are seeking. We would like to follow up on this questionnaire with you in an over-the-phone interview, scheduled at a time that is convenient for you in consideration of the […] zone difference. During the interview, your responses would be documented, and subsequently sent back to you to ensure that we have accurately captured the information you have provided.

We would appreciate any assistance or knowledge that you can provide us on this topic and thank you in advance for your time,

Sincerely,

[INSERT NAME HERE]

Study Team Member

Jacques Whitford Limited

<u>Questionnaire for Environmental and/or Human Health Surveillance Researchers</u>

General Questions

1. How long have you been involved in environmental and/or human health surveillance programs?

Government

To your knowledge,

2. At what level of government are municipal waste incinerators (MWIs) regulated in your country? What branch/department of the government is responsible for MWI regulations?
3. Are environmental surveillance programs a regulatory requirement for MWIs in your country?
4. If yes, what components are required to form a part of such environmental surveillance programs?

Personal Research Activities

5. Who are the stakeholders in your surveillance programs (i.e. government, industry, etc.)?
6. What is the general scope of your surveillance activities?
7. Have all your results been published in the primary literature, and if not, what information on unpublished studies can you provide us?
8. Do you follow any particular best practices and if so, have these been publicly documented or published?
9. What have been the outcomes of your studies? Have they provided useful, measurable results?

Other Activities

10. Are you aware of any further environmental surveillance programs in your country, or in other countries, initiated by the operation of incinerators? If so, can you elaborate on them or provide contact information for someone more familiar with them?
11. Do you know the approximate or range of costs on an annual basis to conduct these programs?
12. Are you familiar with the European Union Human Biomonitoring Network and Pilot Project Activities? If yes, are you involved in it and if so, what is your involvement? Can you provide any details on the goals/logistics of the program?

<u>Comments/Questions/Suggestions</u>

Questionnaire for Government Contacts

General Questions

1. Can you describe the general governmental structure of your country?
2. What is your role within the government?

Municipal Waste Incinerators (MWIs)

3. At what level of government are municipal waste incinerators (MWIs) regulated in your country? What branch/department of the government is responsible for MWI regulations?
4. Are there specific regulations/legislation governing MWIs? When were these implemented?
5. Are environmental surveillance programs a regulatory requirement for MWIs in your country? If not, why?
6. If yes, is Human Biomonitoring (HBM) required to form a part of such environmental surveillance programs? If not, why?
7. If yes, is environmental monitoring required to form a part of such environmental surveillance programs? If not, why?
8. Can you provide us with the regulations or government documents that mandate the programs?
9. Do know the approximate or range of costs on an annual basis to conduct these programs?
10. Are there any changes being contemplated in your country in relation to environmental surveillance and EFW facilities?
11. Do you believe that the environmental surveillance programs that are currently in place are adequate to ensure the protection of public health and the environment? If not, how could they be improved?
12. Does the government conduct HBM in general, not necessarily associated with MWIs, but perhaps as a national health measure, for example? What branch/department of the government would be responsible for this type of activity?

<u>Comments/Questions/Suggestions</u>

<u>Questionnaire for Incinerator Operators</u>

General Questions

1. How long have you been working for/at the municipal waste incinerator (MWI) in question?
2. What is your operational role within the MWI?
3. Can you provide a general overview of the MWI (i.e. capacity, etc.)?

Government

4. To your knowledge, at what level of government is the MWI regulated in your country? What branch/department of the government is responsible for MWI regulations?

Environmental Surveillance

5. Does the MWI conduct an environmental surveillance program, and if so, is it a voluntary activity or a regulatory requirement? If not, why?
6. If such a program exists, what are the components of this program? How long has this program been in operation and for how long will it continue?
7. If Human Biomonitoring (HBM) is a component of the program, is this voluntary or a regulatory requirement?
8. Is the program conducted by MWI employees, government or is it outsourced? Can you provide contact information for the individuals conducting the program?
9. What have been the results of the program to date?
10. Have the results of the program influenced the operation of the incinerator in any measurable way?
11. Would you be able to share the annual costs to conduct your program?
12. Are you aware of any changes being contemplated in your country in relation to environmental surveillance and EFW facilities?
13. Do you believe that the environmental surveillance programs that are currently in place are adequate to ensure the protection of public health and the environment? If not, how could they be improved?

<u>Comments/Questions/Suggestions?</u>

APPENDIX C

Scientific Literature Data Abstraction

As originally described in the Study Protocol, a detailed data abstraction form was used to extract the most relevant information from each article assessed. This consistent approach to data abstraction allowed for a comparative analysis of the data obtained from each article/study. The data abstraction form is quite lengthy, and the process resulted in a cumbersome spreadsheet. For the purposes of brevity and relevance, Appendices C-1 through C-3 contain a shortened version of the final data abstraction containing only the most important process parameters. However, Tables C-1 and C-2 outline the full data abstraction form used in the review at hand.

Table C-1 Full data abstraction form for human biomonitoring studies

Parameter	**Value**
Source	
Study ID	Assigned by Reviewer
Report ID	Assigned by Reviewer
Review Author ID	Assigned by Reviewer
Citation	
Contact Author Affiliation and Details	
Database	
Article Identifier/Digital Object Identifier (DOI)	
Keywords	
Language	
Available Online?	Yes/No
Peer Reviewed?	Yes/No
Abstract	
Eligibility	
Confirm Eligibility for Review	Yes/No
Reason for Exclusion	
Incinerator	
Location of Incinerator (e.g. Country, City, Area)	As described by article author.
Type of Incinerator (will standardize after if possible)	As described by article author.
Study Design	
Study objectives clearly defined	Yes/No
Study hypothesis clearly defined	Yes/No
Study type (cross sectional, longitudinal, retrospective, prospective, survey)	
Was the study type appropriate for the study objective?	Yes/No
Was the study sample representative of the population being studied?	Yes/No
Assignment (mainly for experimental studies)	
Was assignment of participants to study and control group proper?	Yes/No
Was there selection bias?	Yes/No
Was random and blind assignment maintained?	Yes/No
Were the study and control groups comparable?	Yes/No
Participants – Study Group	
Number of Participants	
Age of Participants	
Sex of Participants	
Location of Participants with respect to Incinerator	
Prior Exposure to Chemicals	Yes/No
Comparator Group	Yes/No
Participants – Control Group	
Number of Participants	
Age of Participants	
Sex of Participants	
Location of Participants with respect to Incinerator	
Prior Exposure to Chemicals	Yes/No
Methods/Analytical Procedure	
Study Duration	
Study Start/End Date	
Was Lifestyle Questionnaire Provided to Participants?	Yes/No
Medium Sampled	
Chemicals/Outcome Assessed	
Was the outcome measure appropriate to the objectives of the study?	Yes/No
Was the outcome measure precise and complete?	Yes/No

Did the observation process affect the outcome?	Yes/No
Sampling Location	
Samples Collected By	
Samples Collected In	
Sample Storage Method	
Samples Analyzed By	
Analysis Method	
Were Samples Pooled?	Yes/No
Were Sample Blanks Analyzed?	Yes/No
Was QA/QC Performed?	Yes/No
QA/QC Method	
Results	
Type of Statistical Analysis Performed	
Sample Size	
Were possible confounding variables taken into account?	Yes/No
Was a Test of Significance Performed?	Yes/No
P-Value between Sample and Control	
Was the null hypothesis properly rejected?	Yes/No
Were Type I and II errors considered in the interpretation of the meaning of the significance test?	Yes/No
Correlation of Chemical Levels to Incinerator	Positive/Negative/No Association
Was a proper measure of the size of difference presented?	Yes/No
Was a proper measure of the degree of overlap of the differences presented?	Yes/No
Were the concepts of association, cause and effect properly applied?	Yes/No
Were the limits of the data considered when extrapolating the results?	Yes/No
Was extrapolation to other populations beyond the study population valid?	Yes/No
Assumptions/Limitations of Study	
Biases Identified by Author	
Key Conclusions	
Miscellaneous	
Funding Source	
Further Correspondence with Author(s) Needed?	Yes/No
Contact Information	

Table C-2 Full data abstraction form for environmental monitoring studies

Parameter	Value
Source	
Study ID	Assigned by Reviewer
Report ID	Assigned by Reviewer
Review Author ID	Assigned by Reviewer
Citation	
Contact Author Affiliation and Details	
Database	
Article Identifier/Digital Object Identifier (DOI)	
Keywords	
Language	
Available Online?	Yes/No
Peer Reviewed?	Yes/No
Abstract	
Eligibility	
Confirm Eligibility for Review	Yes/No
Reason for Exclusion	
Incinerator	
Location of Incinerator	As described by article author.
Type of Incinerator	As described by article author.
Study Design	
Study objectives clearly defined	Yes/No
Study hypothesis clearly defined	Yes/No
Study type (cross sectional, longitudinal, retrospective, prospective, survey)	
Was the study type appropriate for the study objective?	Yes/No
Was the study sample representative of the population being studied?	Yes/No
Study Group	
Number of Samples Taken	
Type of Sample Taken	
Location of Samples with respect to Incinerator	
Prior Exposure to Chemicals	
Control Group	
Number of Samples Taken	
Type of Sample Taken	
Location of Samples with respect to Incinerator	
Prior Exposure to Chemicals	Yes/No
Methods/Analytical Procedure	
Study Duration	
Study Start/End Date	
Chemicals/Outcome Assessed	
Was the outcome measure appropriate to the objectives of the study?	Yes/No
Was the outcome measure precise and complete?	Yes/No
Did the observation process affect the outcome?	Yes/No
Samples Collected By	
Samples Collected In	
Sample Storage Method	
Samples Analyzed By	
Analysis Method	
Were Samples Pooled?	Yes/No
Were Sample Blanks Analyzed?	Yes/No
Was QA/QC Performed?	Yes/No
QA/QC Method	
Results	
Type of Statistical Analysis Performed	
Sample Size	
P-Value between Sample and Control	
Were possible confounding variables taken into account?	Yes/No
Was the null hypothesis properly rejected?	Yes/No
Were Type I and II errors considered in the interpretation of the meaning of the significance test?	Yes/No
Was a proper measure of the size of difference presented?	Yes/No
Was a proper measure of the degree of overlap of the differences presented?	Yes/No
Were the concepts of association, cause and effect properly applied?	Yes/No

Were the limits of the data considered when extrapolating the results?	Yes/No
Was extrapolation to other populations beyond the study population valid?	Yes/No
Correlation of Chemical Levels to Incinerator	Positive/Negative/No Association
Assumptions/Limitations of Study	
Biases Identified by Author	
Key Conclusions	
Miscellaneous	
Funding Source	
Further Correspondence with Author(s) Needed?	Yes/No
Contact Information	

APPENDIX C-1A

Human Biomonitoring of Residents - Included

Source			Incinerator			Study Design	Study Group				
Ref ID	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
10	Ardevol, E., Minguillon, C., Garcia, G., Serra, M. E., Gonzalez, C. A., Alvarez, L., Eritja, R., and Lafuente, A. 1999 Public Health Environmental tobacco smoke interference in the assessment of the health impact of a municipal waste incinerator on children through urinary thioether assay	The urinary elimination of thioethers urinary thioethers (UT) was studied in 83 schoolchildren living in two different areas of the city of Mataro, with special attention paid to the influence of a waste incinerator and of the smoking habits of their parents. The mean UT values were 8.79+/-3.23 and 7.52+/-3.23 mmol/mol creatinine in the area close to the incinerator (A1) and in the area far away from it (A2) respectively (statistically n.s.). Children exposed to environmental tobacco smoke (ETS) at home presented increased levels of UT (8.60+/-3.11 vs 5.93+/-3.22 mmol/mol creatinine; P=0.002). Considering the two exposures together (waste incinerator and ETS), no differences were found between the two areas studied (A1 and A2) in non-exposed (ETS) children, whereas slight differences were found when comparing highest ETS exposed children from the two areas (10. 18+/-2.70 vs 8.00+/-3.42 mmol/mol creatinine; P=0.04). Exposure to ETS could affect health more than pollutants from a waste incinerator and may interfere with non-selective assays such as urinary thioethers	Mataro, Spain	Muncipal Solid Waste	Early-Mid 90's	Cross-Sectional, Prospective	39	7-10	Both	Close to incinerator.	None elucidated
21	Bocio, A., Nadal, M., Garcia, F., and Domingo, J. L. 2005 Biological Trace Element Research Monitoring metals in the population living in the vicinity of a hazardous waste incinerator: concentrations in autopsy tissues	This study is a part of a monitoring program for the determination of metals in various human tissues of the population living in the vicinity of a new hazardous waste incinerator (HWI) in Constanti (Tarragona County, Spain). Concentrations of arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), mercury (Hg), manganese (Mn), nickel (Ni), lead (Pb), tin (Sn), thallium (Tl), and vanadium (V) were determined in brain, bone, kidney, liver, and lung autopsy samples collected in 2003 from 22 individuals who had been living for at least 10 yr in the area under evaluation. Results were compared with the metal levels obtained in a baseline study, which was performed during the construction of the HWI (1996--1998). In the present survey, As, Be, Tl, and V levels were not detected in any of the analyzed tissues, while Cr concentrations were very close to the limit of detection. The highest levels of Cd and Hg were found in kidney (17.46 microg/g and 0.23 microg/g, respectively), those of Mn in liver (1.07 microg/g), and those of Ni, Pb, and Sn in bone (1.16 microg/g, 2.11 microg/g, and 0.34 microg/g, respectively). In comparison to the results of the baseline study, a general reduction of most metal concentrations was observed in the current survey	Tarragona, Spain	Hazardous Waste	1999	Longitudinal, Prospective	22	<35 - >65	17 male, 5 female	Not specified. Within zones of Tarragona near HWI.	No occupational exposure.
30	Chen, H. L., Lee, C. C., Liao, P. C., Guo, Y. L., Chen, C. H., and Su, H. J. 2003 Environ.Res. Associations between dietary intake and serum polychlorinated dibenzo-p-dioxin and dibenzofuran (PCDD/F) levels in Taiwanese	The study was conducted to correlate the consumption frequency of different food groups (milk, eggs, fish, and others) and the levels of serum polychlorinated dibenzo-p-dioxin and dibenzofuran (PCDD/F) concentrations of residents living near a municipal waste incinerator. All selected subjects were between 18 and 65 years old and proportionally chosen from each age group based on population distribution. In addition, they had to have lived within a 5-km radius of the incinerator for at least 5 years. Trained interviewers administered a dietary questionnaire interview. Higher serum PCDD/F levels were found in older than in younger subjects, and higher PCDD/F concentrations were found in females than in males. An analysis between the consumption frequency of different foods and serum PCDD/F levels showed that fish might have contributed the highest quantity of measured serum PCDD/Fs. Yet, the regression coefficient of dietary intake and PCDD/F concentration was only 0.017 before and 0.105 after adjusting for the variables of age, gender, and smoking status of the study subjects. The frequency of fish consumption may be the most significant contributor to serum PCDD/F levels. Further research is needed to quantify the association between the consumption of various food groups and their potential contributions to the corresponding serum PCDD/F concentrations	4 incinerators in Northern Taiwan	Not specified.	3 started in 1993; 1 not yet started.	Cross-Sectional, Prospective	282	18-65	50/50 mix	Within 5 km of plant.	Residence minimum 5 years. No occupational exposure.
33	Chen, H. L., Su, H. J., Liao, P. C., Chen, C. H., and Lee, C. C. 2004 Chemosphere Serum PCDD/F concentration distribution in residents living in the vicinity of an incinerator and its association with predicted ambient dioxin exposure	The aim of this study was to evaluate the serum polychlorinated dibenzo-p-dioxin (PCDD) and dibenzofuran (PCDF) concentration distribution in residents living in the vicinity of an incinerator and its association with annual ambient dioxin exposure predicted by an atmospheric dispersion model. A municipal waste incinerator in Northern Taiwan was chosen for this study. This incinerator had been in operation for 6 years at the time of this study. Using the incinerator site as the center, based on the simulated ambient annual average PCDD/F concentrations. Ninety-five volunteers, all live within a radius of 5 km from the incinerator for at least 5 years, who had no occupational exposure potential, were selected based on the population distribution in each district. The average serum PCDD/F concentration for these subjects living within four zones was about 14 pg I-TEQ/g lipid. The serum distribution levels of people of the four study zones, however, were not consistent with the predicted ambient levels. Results also suggest that ambient exposure might not be the most important contributor to serum concentrations when compared to other exposure sources, such as dietary intake	Northern Taiwan	Municipal Waste	~1998	Cross-Sectional, Prospective	76	18-65	50/50 mix	Within 5 km of plant. Sampling locations determined by atmospheric Gaussian modelling.	Residence minimum 5 years. No occupational exposure.
42	De, Felip E., Abballe, A., Casalino, F., di, Domenico A., Domenici, P., Iacovella, N., Ingelido, A. M., Pretolani, E., and Spagnesi, M. 2008 Chemosphere Serum levels of PCDDs, PCDFs and PCBs in non-occupationally exposed population groups living near two incineration plants in Tuscany, Italy	A pilot study was carried out in Tuscany, Italy, to provide preliminary information on the concentrations of polychlorinated dibenzodioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), dioxin-like polychlorobiphenyls (DL-PCBs), and selected non-dioxin-like PCBs (NDL-PCBs) in groups of subjects living in the vicinity of two incineration plants. Seventy-four volunteers were enrolled from areas identified as under a potential impact from incinerator emissions and from not exposed areas. No significant differences were observed between subjects living in the two types of areas. Total concentrations of PCDDs, PCDFs, and DL-PCBs resulted to be in the range 23-30 pg WHO-TEQ g(-1), lipid base, for subjects in the 27-54 year age groups, while concentrations increased to 40-44 pgTEQ g(-1) for the two 55-67 year age groups. The levels of PCDDs and PCDFs were in good agreement with those observed for unexposed population groups in Italy, while the contribution to total TEQ from DL-PCBs was appreciably higher than those currently observed in the general population in Italy and other countries. As to NDL-PCBs, serum levels of the six "indicator" congeners were in the range 240-300 ng g(-1), lipid base, for subjects in the 27-54 year age groups. A raise in NDL-PCB body burden (430-470 ng g(-1), lipid base) was observed for the two 55+ year age groups, in agreement with the expected age-dependent increase. The findings from this study do not show an incremental exposure to PCDDs and PCDFs in the samples from subjects living around the two incineration plants, whereas PCB congener profiles in all samples suggest a possible impact on the area of interest of industrial activities from near industrial settlements	Grosseto, Tuscany, Italy	Municipal, Sanitary, Wood	A: 1976-2000; B: 1997-Present	Cross-Sectional, Prospective	35	27-67	Both	16 within 3 km, 9 within 3-5 km	Residence minimum 20 years.

Source		Control Group					Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Citation	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Study Duration	Was Lifestyle Questionnaire Provided to Participants?	Medium Sampled	Chemicals/Outcome Assessed	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
10	Ardevol, E., Minguillon, C., Garcia, G., Serra, M. E., Gonzalez, C. A., Alvarez, L., Eritja, R., and Lafuente, A. 1999 Public Health Environmental tobacco smoke interference in the assessment of the health impact of a municipal waste incinerator on children through urinary thioether assay	44	7-10	Both	Far away from the incinerator.	None elucidated	1 year	Yes	Urine	Urinary Thioether	Alkaline hydrolysis	Student's t-test and Mann-Whitney	83	Children whose parents smoke and live near incinerator appear to have higher levels than children whose parents smoke and live far from incinerator.	No significant differences found between children in study and control groups, although study group tended to higher values of urinary thioethers. Children exposed to environmental tobacco smoke were significantly more exposed than non-exposed children. In exposed children, children from study group were significantly more exposed than those from control group.	Colegio de Farmaceuticos of Barcelona, Spain	Moderate	Moderate	Moderate	Moderate	Yes
21	Bocio, A., Nadal, M., Garcia, F., and Domingo, J. L. 2005 Biological Trace Element Research Monitoring metals in the population living in the vicinity of a hazardous waste incinerator: concentrations in autopsy tissues	Not explicitely stated, presented in previous study.	N/A	N/A	N/A	N/A	4 years	No, autopsy study.	Brain, bone, kidney, liver, lung.	As, Be, Cd, Cr, Hg, Mn, Ni, Pb, Sn, Tl, V	ICP/MS	Mann-Whitney Test	Varied based on test.	No correlation.	Reduction in metal concentration in tissues over period of evaluation.	Department of Environment, Catalonia	Moderate	Moderate	High	Moderate	Yes
30	Chen, H. L., Lee, C. C., Liao, P. C., Guo, Y. L., Chen, C. H., and Su, H. J. 2003 Environ.Res. Associations between dietary intake and serum polychlorinated dibenzo-p-dioxin and dibenzofuran (PCDD/F) levels in Taiwanese	59	18-65	50/50 mix	Within 5 km of incinerator site - incinerator has not yet begun operation.	Residence minimum 5 years. No occupational exposure.	1 year	Yes	Blood	PCDD/F	GC/MS	ANOVA, PCA, Multiple Regression	341	None identified by authors.	No statistically significant differences between levels of PCDD/F at the four incinerators studied. Highest values observed at the "control group" site. Significantly higher concentrations observed in females, smokers, and older people. Regarding dietary intake, further analysis required to characterize which food groups are main contributors to PCDD/F accumulation. But some association of levels with vegetables, seafood, pork, poultry and dairy products found - however, correlations are small and not biologically meaningful.	Not specified.	Moderate	Moderate	High	Moderate	Yes
33	Chen, H. L., Su, H. J., Liao, P. C., Chen, C. H., and Lee, C. C. 2004 Chemosphere Serum PCDD/F concentration distribution in residents living in the vicinity of an incinerator and its association with predicted ambient dioxin exposure	19	18-65	50/50 mix	Within 5 km of plant. Sampling locations determined by atmospheric Gaussian modelling.	Residence minimum 5 years. No occupational exposure.	Not specified.	Yes	Blood	PCDD/F	GC/MS	Kruskall-Wallis and Mann-Whitney	95	None identified by authors.	No significant differences between average concentrations in each of the four zones. No significant differences between levels in five age groups. Females showed statistically higher level than males. No correlation of serum levels to predicted ambient air levels.	Not specified.	Moderate	Moderate	High	Moderate	Yes
42	De, Felip E., Abballe, A., Casalino, F., di, Domenico A., Domenici, P., Iacovella, N., Ingelido, A. M., Pretolani, E., and Spagnesi, M. 2008 Chemosphere Serum levels of PCDDs, PCDFs and PCBs in non-occupationally exposed population groups living near two incineration plants in Tuscany, Italy	39	29-64	Both	>5km from incinerator.	Residence minimum 20 years.	1 year	Yes	Blood	PCDD/F, PCB	Previously described method - not identified in this paper.	Mann-Whitney and Kruskal-Wallis Test	74	None identified.	No significant differences in serum levels observed between study and control groups. Higher TEQ values found in two 55+ pooled samples, consistent with age dependent increase of body burden found in many other studies. No evidence of increase in body burden due to incineration.	Provincia di Grosseto and Fondazione Monte dei Paschi di Siena	Moderate	Moderate	Moderate	Moderate	Yes

Source			Incinerator			Study Design	Study Group				
Ref ID	**Citation**	**Abstract**	**Location of Incinerator**	**Type of Incinerator**	**Operation Start Date**	**Study type**	**Number of Participants**	**Age of Participants**	**Sex of Participants**	**Location of Samples with respect to Incinerator**	**Prior Exposure to Chemicals**
59	Evans, R. G., Shadel, B. N., Roberts, D. W., Clardy, S., Jordan-Izaguirre, D., Patterson, D. G., and Needham, L. L. 2000 Chemosphere Dioxin incinerator emissions exposure study Times Beach, Missouri	PURPOSE: To determine whether living in the vicinity of a hazardous waste incinerator that was burning material contaminated with 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) increased TCDD and toxicity equivalencies (TEQ) in individuals living near the incinerator. METHODS: Participants were randomly chosen from an area close to the incinerator and compared to participants outside of the exposure area. TCDD and related compounds were measured in blood serum before incineration, four months after incineration started, and at the end of incineration. RESULTS: Lipid adjusted serum levels of TCDD and TEQ decreased from pre-incineration to four months after incineration, and decreased further by the end of incineration. CONCLUSION: Incineration of TCDD did not result in any measurable exposure to the population surrounding the incinerator	Times Beach, Missouri	Hazardous Waste	Not specified.	Longitudinal, Prospective	75	18-64	Unspecified	Within 4-km radius.	None elucidated
65	Fierens, S., Mairesse, H., Heilier, J. F., Focant, J. F., Eppe, G., De, Pauw E., and Bernard, A. 2-1-2007 J.Toxicol.Environ.Health A Impact of iron and steel industry and waste incinerators on human exposure to dioxins, PCBs, and heavy metals: results of a cross-sectional study in Belgium	We evaluated the impact of two iron and steel plants and two municipal solid waste incinerators (MSWI) in Wallonia (Belgium) on the exposure of residents to dioxins, polychlorinated biphenyls (PCBs), and heavy metals. In total, 142 volunteers living around these facilities were recruited and compared with 63 referents from a rural area with no industrial source of pollution. Information about smoking habits, dietary habits, anthropometric characteristics, residential history, and health status was obtained from a self-administered questionnaire. The volunteers provided blood under fasting conditions in order to evaluate the body burden of dioxins (17 polychlorinated dibenzo-p-dioxins/dibenzofurans [PCDD/Fs] congeners) and PCBs. Samples of blood and urine were also taken for the determination of cadmium, mercury, and lead. After adjustment for covariates, concentrations of cadmium, mercury, and lead in urine or blood were not increased in subjects living in the vicinity of MSWIs or sinter plants by comparison with referents. Residents around the sinter plants and the MSWI located in the industrial area had concentrations of dioxins and PCBs in serum similar to that of referents. By contrast, subjects living in the vicinity of the MSWI in the rural area showed significantly higher serum levels of dioxins (geometric mean, 38 vs. 24 pg TEQ/g fat) and coplanar PCBs (geometric mean, 10.8 vs. 7.0 pg TEQ/g fat). Although age-adjusted dioxin levels in referents did not vary with local animal fat consumption, concentrations of dioxins in subjects living around the incinerators correlated positively with their intake of local animal fat, with almost a doubling in subjects with the highest fat intake. These results indicate that dioxins and coplanar PCBs emitted by MSWIs can indeed accumulate in the body of residents who regularly consume animal products of local origin	Thumaide and Pont-de-Loup, Belgium	Municipal Solid Waste	1980 and 1978	Cross-Sectional, Prospective	84	21-80	Unspecified	Within 2 km of incinerator.	Lived within range for 7-22 years (average 18 years). Residents exposed to dioxin emissions above 50 ng TEQ/m3 for close to 20 years.
64	Fierens, S., Mairesse, H., Hermans, C., Bernard, A., Eppe, G., Focant, J. F., and De, Pauw E. 7-25-2003 J.Toxicol.Environ.Health A Dioxin accumulation in residents around incinerators	To evaluate the human exposure impact of municipal waste incinerators, dioxin and coplanar polychlorinated biphenyl (PCB) concentrations were determined in blood of 84 subjects who resided approximately 18 yr in the vicinity of two old incinerators, one located in a rural area (n=51) and the other in an industrial area (n=33). These subjects were compared with 63 controls from an unpolluted area. While no change was found in contaminant levels in residents living around the incinerator in the industrial area, subjects residing around the incinerator in the rural area possessed significantly higher serum levels of dioxins (38 vs. 24 pg TEQ/g fat) and coplanar PCBs (10 vs. 7 pg TEQ/g fat) than controls. These results were confirmed by multiple-regression analysis, showing that residence around the incinerator in the rural area (partial r2=.18) was the major contributor to dioxin accumulation followed by age (partial r2=.07). A two-way analysis of variance (ANOVA) on age-adjusted dioxin levels revealed a significant interaction between residence around incinerators and the consumption of fat from local origin, especially bovine and poultry products. Although age-adjusted dioxin levels in controls did not vary with local animal fat consumption, concentrations of dioxins in subjects living around the incinerators increased proportionally to their intake of local animal fat, with almost a doubling in subjects with a fat intake higher than 150 g fat/wk. Extrapolation from these data suggests that a significant increase of dioxin body burden is likely to occur only when dioxin emissions exceed 5 ng TEQ/Nm3, a threshold considerably above most emissions standards currently in force	Thumaide and Pont-de-Loup, Belgium	Municipal Solid Waste	1980 and 1978	Cross-Sectional, Prospective	84	21-80	Unspecified	Within 2 km of incinerator.	Lived within range for 7-22 years (average 18 years). Residents exposed to dioxin emissions above 50 ng TEQ/m3 for close to 20 years.
95	Kurttio, P., Pekkanen, J., Alfthan, G., Paunio, M., Jaakkola, J. J., and Heinonen, O. P. 1998 Arch.Environ.Health Increased mercury exposure in inhabitants living in the vicinity of a hazardous waste incinerator: a 10-year follow-up	A hazardous-waste-treatment plant that housed an incinerator began operation in 1984, before which a baseline survey of the surrounding population and environment was conducted; 10 y later, investigators studied the same subjects. Researchers focused on mercury exposure because mercury concentrations were present in the stack emissions, and environmental monitoring revealed mercury concentrations near the plant. In 1984 and 1994 the median hair mercury concentrations were 0.5 mg/kg and 0.8 mg/kg, respectively. During the 10-y period, median hair total mercury concentrations increased by 0.35 mg/kg in workers (n = 11); by 0.16 mg/kg, 0.13 mg/kg, and 0.03 mg/kg in individuals who lived 2 km (n = 45), 2-4 km (n = 38), and 5 km (n = 30) from the plant, respectively; and by 0.02 mg/kg in the reference group (n = 55). In summary, mercury exposure increased as distance from the plant decreased; however, the increase in exposure was minimal and, on the basis of current knowledge, did not pose a health risk	Riihimaki, Finland	Hazardous Waste	1984	Longitudinal, Prospective	124	7-64	Unspecified	Varying - from workers to residents at 1.5-2, 2.5-3.7, and 5 km from plant.	Lived there prior to plant operations commencing in 1984 and continued to live there till follow up in 1994.
96	Lee, C. C., Chen, H. L., Su, H. J., Guo, Y. L., and Liao, P. C. 2005 Chemosphere Evaluation of PCDD/Fs patterns emitted from incinerator via direct ambient sampling and indirect serum levels assessment of Taiwanese	The aim of this study was to evaluate the PCDD/Fs patterns in ambient air based on data information emitted from incinerator generated from ambient air measurements and those in serum. Four circular zones, namely A, B, C, and D, were identified based on simulated ambient annual average PCDD/Fs concentrations, from a selected municipal waste incinerator. Sixteen ambient samples were taken from the 4 circular zones across 4-seasons. Eighty-nine volunteers were recruited according to the demographic distribution within each zone. PCDD/Fs profiles were documented both for air and serum samples collected. Comparing to the congener patterns from ambient air and serum samples, we found that OCDD, OCDF, 1,2,3,4,6,7,8-HpCDD, and 1,2,3,4,6,7,8-HpCDF were the predominant groups among 17 congeners from both the ambient air and serum sample. And, factor analysis showed the distribution patterns of PCDD/Fs from ambient air and serum samples are almost identical across different zones, except for congener patterns of serum samples from residents in zone C. In addition, the average PCDD/Fs level significantly reduced for about 10 folds than those of the other three seasons when the incinerator was shut down in one of sampling periods. We might conclude that ambient air exposure was the most important contributor to	Northern Taiwan	Not specified.	~1998	Cross-Sectional, Prospective	70	18-65	~50/50 mix	Within 5 km of plant.	No occupational exposure.

Source		Control Group					Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Citation	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Study Duration	Was Lifestyle Questionnaire Provided to Participants?	Medium Sampled	Chemicals/Outcome Assessed	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
59	Evans, R. G., Shadel, B. N., Roberts, D. W., Clardy, S., Jordan-Izaguirre, D., Patterson, D. G., and Needham, L. L. 2000 Chemosphere Dioxin incinerator emissions exposure study Times Beach, Missouri	75	18-64	Unspecified	Minimum 15km from incinerator.	None elucidated	1 year	Yes	Blood	PCDD/F, PCB	Not specified.	ANCOVA	150	None identified.	Statistically significant decrease in blood levels over course of the study in both study and control groups. No statistically significant differences between study and control groups. Decrease was greater in study group.	Missouri Department of Health, with grant from ATSDR	Moderate	High	High	High	Yes
65	Fierens, S., Mairesse, H., Heilier, J. F., Focant, J. F., Eppe, G., De, Pauw E., and Bernard, A. 2-1-2007 J.Toxicol.Environ.Health A Impact of iron and steel industry and waste incinerators on human exposure to dioxins, PCBs, and heavy metals: results of a cross-sectional study in Belgium	63	33-66	Unspecified	Unspecified, rural unpolluted area.	None elucidated	2 years	Yes	Blood	PCDD/F, PCB, Cd, Hg, Pb	GC/MS	ANOVA	147	Yes for dioxins in rural areas where residents eat large amount of locally produced animal fat.	Same study as Fierens, 2003 with exception of the addition of the analysis of three metals. No significant differences found in metals between study and control groups. The same conclusions were made on the same data with regards to dioxins.	Ministry of the Environment of the Walloon Region, Belgium	Moderate	Moderate	High	Moderate	Yes
64	Fierens, S., Mairesse, H., Hermans, C., Bernard, A., Eppe, G., Focant, J. F., and De, Pauw E. 7-25-2003 J.Toxicol.Environ.Health A Dioxin accumulation in residents around incinerators	63	33-66	Unspecified	Unspecified, rural unpolluted area.	None elucidated	2 years	Yes	Blood	PCDD/F, PCB	GC/MS	ANOVA	147	Yes for rural areas where residents eat large amount of locally produced animal fat.	Statistically significant increase in dioxin levels in rural subjects compared to control. No such difference exists in urban residents. Difference between urban and rural attributed to consumption of locally produced animal fat from bovine and poultry products. Congener fingerprint matches that previously found in local cow's milk and no other major polluter present in rural area. Estimated that 10% rise in body burden likely to result when emissions exceed 5 ng TEQ/m3, which is well above current emissions standards.	Ministry of the Environment of the Walloon Region, Belgium	Moderate	Moderate	High	Moderate	Yes
95	Kurttio, P., Pekkanen, J., Alfthan, G., Paunio, M., Jaakkola, J. J., and Heinonen, O. P. 1998 Arch.Environ.Health Increased mercury exposure in inhabitants living in the vicinity of a hazardous waste incinerator: a 10-year follow-up	55	7-64	Unspecified	30 km from plant.	Lived there prior to plant operations commencing in 1984 and continued to live there till follow up in 1994.	10 years	Yes	Hair, Blood	Hg	AAS	Kruskall-Wallis	179	Increase observed, but not significant enough to produce adverse health effects.	Observed an increase in mercury exposure among workers and among those living near the plant. Increases are small and do not reflect exposures that could cause adverse health effects.	National Public Health Institute, Finland	Moderate	Moderate	High	High	Yes
96	Lee, C. C., Chen, H. L., Su, H. J., Guo, Y. L., and Liao, P. C. 2005 Chemosphere Evaluation of PCDD/Fs patterns emitted from incinerator via direct ambient sampling and indirect serum levels assessment of Taiwanese	19	18-65	~50/50 mix	Within 5 km of plant.	No occupational exposure.	Not specified.	Yes	Blood	PCDD/F	GC/MS	Kruskal-Wallis, Spearman Correlation	89	Serum - None identified. Ambient Air - Major Contibutor	With regards to ambient air concentrations, no differences between the four studied zones overall, though high interseason variability was observed. No statistical relationship between serum levels and ambient air levels with the exception of one congener. Suggests another exposure route is predominant. No assessment done to compare serum levels in four zones. Ambient levels dropped significantly in the	Taiwan Environmental Protection Administration	Moderate	Moderate	High	Moderate	Yes

Source			Incinerator			Study Design	Study Group				
Ref ID	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
99	Leem, J. H., Lee, D. S., and Kim, J. 2006 Arch.Environ.Contam Toxicol. Risk factors affecting blood PCDDs and PCDFs in residents living near an industrial incinerator in Korea	The contamination sources of polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), such as industrial incinerators, can potentially change the blood levels and isomer patterns of PCDD/DFs in residents living near the incinerators. In this study, we estimated whether the blood levels and isomer patterns of PCDD/DFs in residents living near an incinerator were affected by its presence and investigated factors that characterize the risk of high exposure to PCDD/DFs in the area. We estimated the blood levels and homologue patterns of PCDD/DFs in a group of 40 residents living within 5 km of an industrial incinerator and in a group of 20 residents living 20 km away from an incinerator. We cannot assert that the operation of incinerator facilities was only cause of increased PCDD/DFs in these residents; however, the operation of incinerator facilities in agricultural areas increased PCDD/DF exposure to individuals. The group living next to the industrial incinerator especially represented the typical isomer pattern in which the proportions of OCDDs were lower and those of PCDFs higher than those in the other groups. The high-risk population with increased blood levels of PCDD/DFs included those who had lived longer in the contaminated area as well as those who frequently ate contaminated foods	Pyeongtaek, Korea	Industrial Waste	1998 (Closed in 2001)	Cross-Sectional, Prospective	40	Unspecified.	Unspecified	Residence within 5 km.	None elucidated
101	Llobet, J. M., Granero, S., Torres, A., Schuhmacher, M., and Domingo, J. L. 1998 Trace Elements and Electrocytes Biological monitoring of environmental pollution and human exposure to metals in Tarragona, Spain. III. Blood levels	Blood samples were obtained from 72 men and 72 women (age > 16 years) living in 3 residential areas in the vicinity of a new hazardous waste incinerator (HWI), now under construction (Tarragona, Spain). The samples were subjected to arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), mercury (Hg), manganese (Mn), nickel (Ni), lead (Pb), tin (Sn), thallium (Tl), and vanadium (V) analyses. Beryllium, Cd, Cr, Mn, Ni, Pb, Tl, Sn, and V were measured by ICP-MS. Arsenic and Hg were determined by using hydride generation/ICP-MS. Results were analyzed in terms of age, sex, and specific place of residence. Arsenic, Be, Tl, and V levels were under the respective detection limits. The geometric mean concentrations and ranges (mug/dl) of the remaining elements were the following: Cd 0.70 (0.20-3.24), Cr 0.02 (0.01-0.11), Hg 0.68 (0.37-3.54), Mn 1.90 (0.35-14.90), Ni 1.39 (0.08-8.81), Pb 3.83 (1.20-27.91), and Sn 1.14 (0.007-9.30). No differences in relation to sex were observed. In turn, only Cr (men) and Hg (men and women) concentrations were significantly increased with age. However, significant differences depending on the place of residence of the subjects were noted in the blood concentrations of Cd, Hg, Mn, and Pb. The current blood levels of Cd, Mn, and Pb show some remarkable differences compared to those found in previous surveys	Tarragona, Spain	Hazardous Waste	1999	Cross-Sectional, Prospective	144	>16	Both	N/A	Potentially. Residents pulled from urban area, areas near oil refineries, MWI. No known occupational exposure. Min residence 10 years.
127	Nadal, M., Bocio, A., Schuhmacher, M., and Domingo, J. L. 2005 Biological Trace Element Research Monitoring metals in the population living in the vicinity of a hazardous waste incinerator: levels in hair of school children	Hair samples of 134 school children (12-14 yr old) living in three residential zones in the vicinity of a new hazardous waste incinerator (HWI) (Constanti, Tarragona County, Catalonia, Spain) were analyzed by inductively coupled plasma-mass spectrometry (ICP-MS) for arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), mercury (Hg), manganese (Mn), nickel (Ni), lead (Pb), tin (Sn), thallium (Tl), and vanadium (V) concentrations. These concentrations were compared with those obtained in a baseline survey performed in the same area during the period of construction of the HWI. Current mean concentrations ranged from values under the respective limit of detection (As, Be, Cd, Tl, and V) to 0.70 and 0.86 microg/g for Hg and Pb, respectively. In comparison to the baseline survey, the levels of Cr, Mn, Ni, Pb, and Sn showed a significant reduction, whereas Hg concentrations were similar. No significant differences were observed according to the sex of the children. However, some differences were noted, especially for Pb and Cr, with respect to the specific zone of residence. In general terms, the current metal levels in hair of school children are similar or even lower than those recently reported for a number of industrial and residential areas of various regions and countries	Tarragona, Spain	Hazardous Waste	1999	Longitudinal, Cross-Sectional, Prospective	134	14-Dec	53 male, 81 female	Some near incinerator, others near other industry, others in urban downtown.	Potentially. Some children from areas with MWI, oil refineries.
139	Park, S., Kim, S. J., Kim, K. S., Lee, D. S., and Kim, J. G. 7-15-2004 Environ.Sci.Technol. Influence of an industrial waste incinerator as assessed by the levels and congener patterns of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans	To assess the spatial change in the influence of an industrial waste incinerator, a total of 47 soil samples (in continuous manner with distance) and 65 human blood samples (40 within 5 km and 20 at 7 and 12 km) were analyzed for polychlorinated dibenzo-p-dioxins/polychlorinated dibenzofurans (PCDD/Fs). The influence was not clearly observed both on the soil and blood levels of PCDD/Fs as the levels in the near zone (within 5 km) were not statistically different from those in the far zones at 7 and 12 km. Assessment was conducted on the congener patterns by using principal component analysis and by characterizing the congener fractions as a function of distance. In soil, the congener fractions of 2,3,4,7,8-PeCDF, 1,2,3,4,7,8-HxCDF, 1,2,3,6,7,8-HxCDF, 1,2,3,4,6,7,8-HpCDF, and OCDF decreased progressively with the distance. Blood was consistent with soil in that each congener fraction of these PCDFs (except OCDF) was statistically greater in the near zone than the far zones. The decreases in these PCDFs were balanced by OCDD in both soil and blood. It was concluded that although not obviously observed in the contamination levels, the influence of the incinerator was clearly shown by the congener patterns of PCDD/Fs in both soil and blood that changed with distance	Pyoungtak, Korea	Industrial Waste	1998-2001	Cross-Sectional, Prospective	40	>20	Unspecified	Within 5 km of plant.	Minimum residence 5 years.
146	Reis, M. F., Miguel, J. P., Sampaio, C., Aguiar, P., Melim, J. M., and Papke, O. 2007 Chemosphere Determinants of dioxins and furans in blood of non-occupationally exposed populations living near Portuguese solid waste incinerators	Biomonitoring of dioxin body burden, as evaluated by PCDD/F levels in blood, has been carried out in a total of 138 adults from general population living in the vicinity of solid waste incinerators in Portugal. Measurements were performed included in cross-sectional surveys within two Environmental Health Surveillance Programs launched in response to ecotoxicological concern in relation to solid waste incinerators near Lisbon and in Madeira Island. Overall conclusion from first published results is indicative that dioxin exposure of global populations cannot be related to the emissions of these facilities, meaning that dioxin sources control seems to be effective in relation to both incinerators. Main objective of present work was to investigate potential determinants of dioxin levels in the studied populations. Findings from this investigation also suggest that incineration does not impact on dioxin blood levels of nearby residents. Follow-up of a small group of individuals (22) from Lisbon gives preliminary indication on temporal control effectiveness of the Lisbon facility. Regarding comparison between PCDD/F levels from Lisbon [illegible]	Lisbon and Madeira Island, Portugal	Municipal Solid Waste	1999 (Lisbon) / 2002 (Madeira)	Cross-Sectional, Prospective	65	18-65	Both	Unspecified	No known occupational exposure. Residence min. 1 year.

Source		Control Group					Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Citation	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Study Duration	Was Lifestyle Questionnaire Provided to Participants?	Medium Sampled	Chemicals/Outcome Assessed	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
99	Leem, J. H., Lee, D. S., and Kim, J. 2006 Arch.Environ.Contam Toxicol. Risk factors affecting blood PCDDs and PCDFs in residents living near an industrial incinerator in Korea	20	Unspecified.	Unspecified	Residence within 20 km.	None elucidated	Not specified.	Yes	Blood	PCDD/F	GC/MS	Mann-Whitney Test	60	None identified.	No signficant difference observed between study and control groups. However, compared to a 5-sample no-industry agricultural zone, levels were generally higher. Levels increased with age and length of residence. Farmers had higher levels than indoor workers, possible cause application of pesticides as pentachlorophenol is a suspected local contaminant. Positive correlation with fish intake, and smoking. Global conclusion is that incinerator facilities are not the sole cause of increased PCDD/F concentrations	Ministry of Environment, Korea	Moderate	Moderate	High	High	Yes
101	Llobet, J. M., Granero, S., Torres, A., Schuhmacher, M., and Domingo, J. L. 1998 Trace Elements and Electrocytes Biological monitoring of environmental pollution and human exposure to metals in Tarragona, Spain. III. Blood levels	Baseline Study	N/A	N/A	N/A	N/A	1 year	Yes	Blood	As, Be, Cd, Cr, Hg, Mn, Ni, Pb, Sn, Tl, V	ICP/MS and Hydride Generation	ANOVA, Mann-Whitney	Varied based on test.	No correlation - baseline study.	No signficant differences in metal concentrations between sexes. In relation to age, only Cr (men) and Hg (both). Some differences based on living environment.	Department of Environment, Catalonia	Moderate	Moderate	High	High	Yes
127	Nadal, M., Bocio, A., Schuhmacher, M., and Domingo, J. L. 2005 Biological Trace Element Research Monitoring metals in the population living in the vicinity of a hazardous waste incinerator: levels in hair of school children	N/A - comparison to baseline study (line above)	N/A	N/A	N/A	N/A	5 years	Yes	Hair cut from area close to occipital region of scalp.	As, Be, Cd, Cr, Hg, Mn, Ni, Pb, Sn, Tl, V	ICP/MS	Kruskal-Wallis test	Varied based on test.	None identified.	No relationship between sex and metal levels. Some differences based on living environment. Overall - Levels of metals decreased notably after 5 years. Impact of facility on the area is not significant.	Not specified.	Moderate	Moderate	High	High	Yes
139	Park, S., Kim, S. J., Kim, K. S., Lee, D. S., and Kim, J. G. 7-15-2004 Environ.Sci.Technol. Influence of an industrial waste incinerator as assessed by the levels and congener patterns of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans	25	>20	Unspecified	20 samples at 12 km from plant, 5 samples from adjacent clean agricultural area.	Minimum residence 5 years.	1 year	Yes	Blood	PCDD/F	GC/MS	PCA	65	Partial correlation since congener profiles in soil and blood at near zone were similar.	No statistically significant differences between levels of PCDD/F in near and far zones. However, both zones had statistically higher levels than the clean, agricultural zone. Levels in near and far zones comparable to previous study of Seoul, Korea. Congener patterns from the two zones were statistically different. Conclude that incinerator implied partial impact of incinerator since congener profiles of blood and soil in near zone were similar. Degree of elevation of PCDD/F levels in soil with distance was ambiguous. No significant difference in dietary practices between two zones.	Not specified.	Moderate	Moderate	High	Moderate	Yes
146	Reis, M. F., Miguel, J. P., Sampaio, C., Aguiar, P., Melim, J. M., and Papke, O. 2007 Chemosphere Determinants of dioxins and furans in blood of non-occupationally exposed populations living near Portuguese solid waste incinerators	51	18-65	Both	Unspecified	No known occupational exposure. Residence min. 1 year.	4 years	Yes	Blood	PCDD/F	GC/MS	Mann-Whitney Test	116	No correlation.	No stastically significant difference between study and control groups. Residents of urban Lisbon show statistically significant differences (higher) than residents of more rural Madeira.	VALORSUL - Incinerator corporation in Lisbon. Regional Ministry of Environment and Natural Resources - Madeira.	Moderate	Moderate	Moderate	Moderate	Yes

Source			Incinerator			Study Design	Study Group				
Ref ID	**Citation**	**Abstract**	**Location of Incinerator**	**Type of Incinerator**	**Operation Start Date**	**Study type**	**Number of Participants**	**Age of Participants**	**Sex of Participants**	**Location of Samples with respect to Incinerator**	**Prior Exposure to Chemicals**
145	Reis, M. F., Sampaio, C., Aguiar, P., Mauricio, Melim J., Pereira, Miguel J., and Papke, O. 2007 Chemosphere Biomonitoring of PCDD/Fs in populations living near portuguese solid waste incinerators: levels in human milk	In the context of two Environmental Health Surveillance Programs, launched in response to public and scientific concern in relation to waste incinerators located near Lisbon and in Madeira Island, two human biomonitoring projects have been started in Portugal, focussed in dioxins and dioxin-like compounds in human milk. Results from the undertaken studies have already provided data on the extent and pattern of dioxin body burden of both studied groups as well as a preliminary temporal trend of dioxin levels for the population residing near Lisbon incinerator. The present paper investigates difference between exposed and non-exposed subjects under study and, from a preventive perspective, possible covariates of the dioxin levels in human milk. Emissions from both incinerators appear to be well controlled as there is no increase of human body burden of dioxins as measured in human milk of individuals living near these facilities. Concerning other determinants of dioxin levels, results suggest confirmation of previously found significant age-dependent trend towards higher levels of dioxins in aged subjects. On the contrary, association between mother's levels of dioxins and parity lost significance. Apart from the issue of incineration, the general conclusion for the general population is that living in Lisbon as compared to Madeira results in higher milk dioxin levels and possible health risks. The profile of the single congeners for PCDD/Fs in human milk from Madeira and Lisbon shows similar contributions for 12378-PCDD, 23478-PCDF, 123678-HCDD and 2378-TCDD, that account altogether for about 84% of the total identified dioxin body burden in the studied groups	Lisbon and Madeira Island, Portugal	Municipal Solid Waste	1999 (Lisbon) / 2002 (Madeira)	Cross-Sectional, Prospective	73	Unspecified, but assumed adult or young adult, as all are pregnant.	Female	Reside within 5 km.	No known occupational exposure. Residence min. 1 year.
148	Reis, M. F., Sampaio, C., Brantes, A., Aniceto, P., Melim, M., Cardoso, L., Gabriel, C., Simao, F., and Miguel, J. P. 2007 Int.J.Hyg.Environ.Health Human exposure to heavy metals in the vicinity of Portuguese solid waste incinerators--Part 1: biomonitoring of Pb, Cd and Hg in blood of the general population	Human exposure to heavy metals makes it necessary to monitor these elements in the human body if the objective is to relate heavy metal exposure to adverse health effects. In Portugal, biomonitoring projects on heavy metals are being carried out on people living in the vicinity of solid waste incinerators. The projects are being developed in the ambit of two environmental health surveillance programs related to solid waste incineration facilities, one near Lisbon and the other on Madeira Island, that have the main objective of guaranteeing the safeguard of public health in relation to the potential negative impact of incineration processes on human health. These programs are the only ones in the country that integrate a systematic observation of human exposure to heavy metals as determined by the respective body burden in several population groups. Therefore, they are the only ones that are currently able to provide systematic data from Portuguese regions on the extent and pattern of human exposure to this type of pollutants. The present paper is the first of a series of three prepared papers with the objective of presenting and discussing available data. It addresses exposure to lead, cadmium and mercury as determined by their levels in blood of general population adults. Results suggest the effectiveness of source control measures in relation to both incinerators under study, similarly to what has been concluded from previous studies addressing exposure to dioxins. They also show, in relation to the baseline situation, a general significant trend for reduction of exposure to all studied heavy metals. Individuals from Lisbon seem to have a significantly higher body burden of the studied metals than those living in Madeira and, in general, metal exposure in men is significantly higher than in women, with the most relevant exception being the case of higher mercury levels in women, at the baseline and for both communities. Compared with published reference values for similar conditions, blood levels of cadmium, lead, and mercury of the present investigation seem to be relatively higher, in median terms and for extreme values, mainly in the case of cadmium and mercury. In the case of lead the differences are not so marked	Lisbon and Madeira Island, Portugal	Municipal Solid Waste	2000 (Lisbon) / 2002 (Madeira)	Longitudinal, Cross-Sectional, Prospective	Lisbon - 136 in T0, 75 in T1/T2; Madeira - 55	18-65	Both	Within 5km (Lisbon); 3km (Madeira)	No known occupational exposure. Residence min. 1 year.
150	Reis, M. F., Sampaio, C., Brantes, A., Aniceto, P., Melim, M., Cardoso, L., Gabriel, C., Simao, F., Segurado, S., and Miguel, J. P. 2007 Int.J.Hyg.Environ.Health Human exposure to heavy metals in the vicinity of Portuguese solid waste incinerators--Part 2: biomonitoring of lead in maternal and umbilical cord blood	As part of environmental health surveillance programs related to solid waste incinerators located near Lisbon and on Madeira Island, human biomonitoring projects have been implemented in Portugal, some of them focused on cross-sectional surveys of heavy metals in blood. One of the general aims of these programs is to provide Portuguese data on the extent and pattern of human exposure to the pollutants potentially released in the stack gases from the incinerators, namely heavy metals. The present investigation reports information specifically on blood lead levels of newborn-mother pairs living in the vicinity of the incinerators under study, as well as of statistically similar participants living outside the exposed area. For Lisbon, lead levels determined at the baseline period (T0), as well as three subsequent evaluations of potential specific impacts of the incinerator (T1, T2 and T3) are described in order to investigate spatial and temporal trends of human exposure to lead. Available data for Madeira, namely lead levels in blood from the study population before the incinerator started operation, is also described. For Lisbon, analyses showed a statistically significant decrease of lead concentrations in maternal ($p<0.001$) and umbilical cord blood ($p<0.001$) during the whole monitoring period. Practically "overt" transplacental exposure to lead was observed only in the Lisbon biomonitoring project and for some cross-sectional surveys. Baseline levels for Madeira were the lowest found in all observations already performed in both programs (maternal and umbilical cord mean lead levels of 0.4 microg/dl and 0.3 microg/dl, respectively). No statistical associations have been found between lead levels in blood and age neither for global populations from Lisbon and Madeira nor for specific groups included in the different observational periods	Lisbon and Madeira Island, Portugal	Municipal Solid Waste	2000 (Lisbon) / 2002 (Madeira)	Longitudinal, Cross-Sectional, Prospective	Lisbon - 133; Madeira - 31	17-52	Female	Within 5km (Lisbon); 3km (Madeira)	No known occupational exposure. Residence min. 1 year.
107	Reis, M. F., Sampaio, C., Brantes, A., Aniceto, P., Melim, M., Cardoso, L., Gabriel, C., Simao, F., and Miguel, J. P. 2007 Int.J.Hyg.Environ.Health Human exposure to heavy metals in the vicinity of Portuguese solid waste incinerators--Part 3: biomonitoring of Pb in blood of children under the age of 6 years	As a part of environmental health surveillance programs related to Portuguese solid waste incinerators (SWI), two biomonitoring projects have been established to investigate additional exposure to lead in children under the age of 6 years living in the vicinity of those facilities. The above-mentioned programs, being the only ones in the country that integrate systematic observations on human exposure to heavy metals, have to provide systematic data from Portuguese regions on the extent and pattern of human exposure to heavy metals, namely to lead. The present paper is the third of a series of papers prepared to accomplish that objective in regards to lead exposure as evaluated by measuring lead levels in children under the age of 6 years. Altogether, 250 children from Lisbon and 247 from Madeira Island have already been involved in the investigation. The present study evaluates spatial and temporal trends of lead exposure, based on comparisons of children's blood lead levels, either stratified by living area (exposed and control groups), or by time of exposure (T0, the baseline time, and T1, after approximately 2 years of regular operation of the facilities). The results obtained correspond to a relatively reduced number of individuals. Possibly for this reason, they are not fully conclusive in relation to whether living in the vicinity of SWI represents an additional risk of higher exposure to lead. Time trends of lead exposure as evaluated by blood lead levels in children also do not show any clear pattern. These conclusions and the fact that altogether around 3% of children from the whole group have blood lead levels >or=10 microg/dl warrant further investigation in order to clarify the contribution of incinerator emissions to the levels of lead in children and to identify alternative sources for preventive purposes, taking into	Lisbon and Madeira Island, Portugal	Municipal Solid Waste	2000 (Lisbon) / 2002 (Madeira)	Longitudinal, Cross-Sectional, Prospective	Lisbon - 97; Madeira - 124	1-6	Both	Within 5km (Lisbon); 3km (Madeira)	No known occupational exposure. Residence min. 1 year.
157	Schroijen, C., Baeyens, W., Schoeters, G., Den, Hond E., Koppen, G., Bruckers, L., Nelen, V., Van de, Mieroop E., Bilau, M., Covaci, A., Keune, H., Loots, I., Kleinjans, J., Dhooge, W., and van, Larebeke N. 2008 Chemosphere Internal exposure to pollutants measured in blood and urine of Flemish adolescents in function of area of residence	The Centre for Environment and Health in Flanders, the Northern part of Belgium, started a biomonitoring program on adolescents in 2003. 1679 adolescents residing in nine areas with different patterns of pollution participated in the study. Possible confounding effects of lifestyle and personal characteristics were taken into account. The geometric mean levels of cadmium and lead in whole blood amounted to 0.36 and 21.7 microg l(-1), those of PCBs, DDE and HCB in serum to 68, 94 and 20.9 ng g(-1) fat, and those of 1-hydroxypyrene and t,t'-muconic acid in urine to 88 ng g(-1) creatinine and 72 microg g(-1) creatinine. Significant regional differences in internal lead, cadmium, PCBs, DDE and HCB exposure were observed in function of area of residence, even after adjustment for age, sex, smoking (and body mass index for the chlorinated compounds). Compared to a reference mean, internal exposure was significantly higher in one or more of the areas: Cd and Pb in the Antwerp agglomeration, Cd in the Antwerp harbour, PCBs in the Ghent agglomeration, PCBs, DDE and HCB in the Ghent harbour, Cd, PCBs, DDE and HCB in the rural area, DDE in Olen and in the Albert canal areas. Adolescents living in an area with intensive fruit cultivation (showing overall the lowest values) and, surprisingly, in areas around household waste incinerators (average of six areas), had no significantly increased internal exposures. Subjects from separate areas around waste incinerators showed significant differences in body load of various environmental contaminants	Belgium	Municipal Solid Waste	Variable	Cross-Sectional, Prospective	207	13-16	53.1% males; balance female (for entire study)	Immediate surroundings of 12 municipalities containing MWIs	Minimum residence 5 years.

Source		Control Group					Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Citation	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Study Duration	Was Lifestyle Questionnaire Provided to Participants?	Medium Sampled	Chemicals/Outcome Assessed	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
145	Reis, M. F., Sampaio, C., Aguiar, P., Mauricio, Melim J., Pereira, Miguel J., and Papke, O. 2007 Chemosphere Biomonitoring of PCDD/Fs in populations living near portuguese solid waste incinerators: levels in human milk	108	Unspecified, but assumed adult or young adult, as all are pregnant.	Female	Reside/work more than 5 km from plant.	No known occupational exposure. Residence min. 1 year.	4 years	Yes	Breast Milk	PCDD/F	GC/MS	Mann-Whitney Test	181	No correlation.	No stastically significant difference between study and control groups. Residents of urban Lisbon show statistically significant differences (higher) than residents of more rural Madeira.	VALORSUL - Incinerator corporation in Lisbon. Regional Ministry of Environment and Natural Resources - Madeira.	Moderate	High	High	Moderate	Yes
148	Reis, M. F., Sampaio, C., Brantes, A., Aniceto, P., Melim, M., Cardoso, L., Gabriel, C., Simao, F., and Miguel, J. P. 2007 Int.J.Hyg.Environ.Health Human exposure to heavy metals in the vicinity of Portuguese solid waste incinerators--Part 1: biomonitoring of Pb, Cd and Hg in blood of the general population	Lisbon - 30 in T0, 75 in T1/T2; Madeira - 55	18-65	Both	Further than 5km (Lisbon); 3km (Madeira)	No known occupational exposure. Residence min. 1 year.	4+ years	Yes	Blood	Pb, Cd, Hg	AAS	Mann-Whitney Test	110-168	No correlation.	Lack of stastically significant difference between study and control groups. Where differences exist, too small to be relevant. Residents of urban Lisbon show statistically significant differences (higher) than residents of more rural Madeira. General significant trend for reduction when compared to the baseline period.	VALORSUL and VALOR AMBIENTE - entities responsible for the incinerators.	Moderate	High	Moderate	Moderate	Yes
150	Reis, M. F., Sampaio, C., Brantes, A., Aniceto, P., Melim, M., Cardoso, L., Gabriel, C., Simao, F., Segurado, S., and Miguel, J. P. 2007 Int.J.Hyg.Environ.Health Human exposure to heavy metals in the vicinity of Portuguese solid waste incinerators--Part 2: biomonitoring of lead in maternal and umbilical cord blood	Lisbon - 205; Madeira - 48	17-52	Female	Further than 5km (Lisbon); 20km (Madeira)	No known occupational exposure. Residence min. 1 year.	4+ years	Yes	Blood from parturients and newborns umbilical cords before labor and after delivery respectively.	Pb	AAS	Mann-Whitney Test	30-145	No correlation.	Although some stastically significant difference between study and control groups was observed, where differences exist, too small to be relevant. Residents of urban Lisbon show statistically significant differences (higher) than residents of more rural Madeira. General significant trend for reduction when compared to the baseline period. Blood lead levels well below CDC action level.	VALORSUL and VALOR AMBIENTE - entities responsible for the incinerators.	Moderate	High	Moderate	High	Yes
107	Reis, M. F., Sampaio, C., Brantes, A., Aniceto, P., Melim, M., Cardoso, L., Gabriel, C., Simao, F., and Miguel, J. P. 2007 Int.J.Hyg.Environ.Health Human exposure to heavy metals in the vicinity of Portuguese solid waste incinerators--Part 3: biomonitoring of Pb in blood of children under the age of 6 years	Lisbon - 153; Madeira - 123	1-6	Both	Further than 5km (Lisbon); 3km (Madeira)	No known occupational exposure. Residence min. 1 year.	4+ years	Yes	Blood	Pb, Hg	AAS	Mann-Whitney Test	114-130	Differences observed between study and control groups were statistically significant, though concentrations were not always higher in study group. Therefore, no conclusion made on this topic.	Results justify need for further investigation. Differences observed between study and control were significant though not always higher in study group. Urban Lisbon showed higher levels than Madeira. Reduction or no change in levels over time observed. 14 children had concentrations above CDC action limit.	VALORSUL and VALOR AMBIENTE - entities responsible for the incinerators.	Moderate	High	Moderate	High	Yes
157	Schroijen, C., Baeyens, W., Schoeters, G., Den, Hond E., Koppen, G., Bruckers, L., Nelen, V., Van de, Mieroop E., Bilau, M., Covaci, A., Keune, H., Loots, I., Kleinjans, J., Dhooge, W., and van, Larebeke N. 2008 Chemosphere Internal exposure to pollutants measured in blood and urine of Flemish adolescents in function of area of residence	1472	13-16	53.1% males; balance female (for entire study)	Spread out in different target areas across Flanders.	Minimum residence 5 years.	1 year	Yes, to adolescents and parents.	Blood, Urine	Pb, Cd, PCB, DDE, HCB, PAH metabolite, Benzene metabolite	ICP/MS (metals); GC/EC (PCB, pesticides); HPLC/F (metabolites)	ANOVA	1679	None identified.	No stastically significant differences between mean incinerator values and overall mean values. Some significant differences when looking at individual incinerators (even mix of higher than and lower than reference mean). Overall results of study are in line with biomonitoring studies from similar industrialized countries.	Ministry of the Flemish Community	Moderate	High	High	Moderate	Yes

Source			Incinerator			Study Design	Study Group				
Ref ID	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
169	Schuhmacher, M., Domingo, J. L., Hagberg, J., and Lindstrom, G. 2004 Chemosphere PCDD/F and non-ortho PCB concentrations in adipose tissue of individuals living in the vicinity of a hazardous waste incinerator	To assess the influence of a new hazardous waste incinerator (HWI) on public health, a preoperational monitoring program was established during the period of construction. In this study, the levels of polychlorinated dibenzo-p-dioxins (PCDD) and dibenzofurans (PCDF) accumulated in adipose tissue of 15 autopsied subjects living in the area under potential impact of the HWI were determined after approximately 3 years of regular operations in the facility. The non-ortho PCBs 77, 126 and 169 were also determined. PCDD/F concentrations ranged between 1.5 and 41 pg WHO-TEQ/g fat (2.4 and 72 WHO-TEQ/g fat, respectively, including PCBs), with a mean value of 11 pg WHO-TEQ/g fat and a median value of 7.4 pg WHO-TEQ/g fat (22 and 13 WHO-TEQ/g fat, respectively, including PCBs). In the baseline study, the mean level of PCDD/Fs was 36 pg WHO-TEQ/g fat (61 pg WHO-TEQ/g fat, including non-ortho PCBs 77, 126 and 169), which means a reduction of 70% (64% including PCBs). This notable reduction is in accordance with the important decrease observed in recent years in PCDD/F intake through the diet. The current concentrations of PCDD/Fs in human adipose tissue, as well as recent data on PCDD/F levels in plasma and breast milk of subjects living in the vicinity of the same HWI, indicate that there is not any additional significant exposure to PCDD/Fs for this population	Tarragona, Spain	Hazardous Waste	1999	Longitudinal, Prospective	15	19-94	4 women, 11 men	7 samples - industrial; 8 samples - urban	Potentially. Residents pulled from urban area, areas near oil refineries, MWI. No known occupational exposure. Min residence 10 years.
168	Schuhmacher, M., Domingo, J. L., Kiviranta, H., and Vartiainen, T. 2004 Chemosphere Monitoring dioxins and furans in a population living near a hazardous waste incinerator: levels in breast milk	In this study, the concentrations of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDFs) in breast milk from mothers living in the vicinity of a new hazardous waste incinerator (HWI) were determined. Monitoring was performed after three years of regular operations in the facility and the present results were compared with baseline concentrations obtained in a pre-operational program. PCDD/PCDF levels were determined by HRGC/HRMS in 15 samples. In the present study, PCDD/PCDF concentrations ranged from 4.9 to 39.9 pg I-TEQ/g fat (5.1-46.8 pg WHO-TEQ/g fat), with a median value of 7.7 pg I-TEQ/g fat (9.1 pg WHO-TEQ/g fat). In the baseline survey, PCDD/PCDF concentrations ranged between 5.9 and 17.1 pg I-TEQ/g fat, with a median value of 11.7 pg I-TEQ/g fat. In relation to this, a percentage of reduction of 34.2% was noted. This decrease is in agreement with the relevant reduction found in the dietary intake of PCDD/PCDFs between both surveys. The results of the present study, as well as other recent environmental and biological data, indicate that living in the vicinity of this HWI should not mean additional health risks due to PCDD/PCDFs for the general population	Tarragona, Spain	Hazardous Waste	1999	Longitudinal, Prospective	15	25-35	Female	7 samples - 7-10 km from HWI (urban); 8 samples - 4-8 km from HWI (petrochem)	Potentially. Residents pulled from urban area, areas near oil refineries, MWI. No known occupational exposure. Min residence 5 years.
170	Schuhmacher, M., Domingo, J. L., Llobet, J. M., Kiviranta, H., and Vartiainen, T. 1999 Chemosphere PCDD/F concentrations in milk of nonoccupationally exposed women living in southern Catalonia, Spain	Concentrations of 17 toxic 2,3,7,8-substituted polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) have been determined in pooled samples of breast milk from 15 mothers living in two residential areas (Tarragona downtown and an industrial area) in the vicinity of a new hazardous waste incinerator (HWI), now under construction in Tarragona (southern Catalonia, Spain). PCDD/Fs in human milk samples ranged between 5.9 and 17.1 pg I-TEQ/g fat (162-498 pg I-TEQ/l), with a mean value of 11.8 pg I-TEQ/g fat (310.8 pg I-TEQ/l). The percentages of fat ranged between 1.53 and 3.52. Although PCDD/F levels in milk from mothers living in the industrial area were found to be slightly higher than those observed in women living Tarragona downtown, most differences did not reach the level of statistical significance. In general terms, PCDD/F concentrations in human milk (pooled) samples of mothers living in the area of Tarragona are similar or lower than those previously reported for most industrialized countries	Tarragona, Spain	Hazardous Waste	1999	Cross-Sectional, Prospective	15	25-35	Female	Near urban downtown or petrochem complex.	Potentially. Residents pulled from urban area, areas near oil refineries, MWI. No known occupational exposure. Min residence 5 years.
163	Schuhmacher, M., Kiviranta, H., Vartiainen, T., and Domingo, J. L. 2007 Chemosphere Concentrations of polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) in milk of women from Catalonia, Spain	In this study, the concentrations of polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) in milk from women living in the vicinity of a new hazardous waste incinerator (HWI) in Catalonia, Spain, were determined. The study was performed after 4 years of regular operations in the facility and the present PCB levels were compared with baseline concentrations obtained in a pre-operational program. PCBs and PBDEs levels were determined by HRGC/HRMS in 15 samples. In the present study planar PCBs ranged from 1.3 to 6.3 pg WHO-TEQ/g fat with a mean value of 3.8 pg WHO-TEQ/g fat. After adding dioxin-like mono-ortho-PCBs the total PCB-TEQ concentrations ranged from 3.8 to 13.3 pg WHO-TEQ/g fat (mean value: 8.7 pg WHO-TEQ/g fat). A comparison of the current data with those obtained in the baseline study showed significant decreases for both planar and total WHO-TEQ of PCBs: 47.9% and 44.6%, respectively. PCB concentrations in milk of women living in urban zones were higher than those living near industrial areas (10.1 and 7.4 pg WHO-TEQ/g fat, respectively). Mean PBDE concentrations were 2.2 and 2.5 ng/g fat for women living in urban and industrial zones, respectively. Dietary intake of PCBs and PBDEs for a standard adult woman samples were 898 and 843 ng/day for PCBs, and 72 and 63 ng/day for PBDEs, for residents in urban and industrials areas, respectively. This study suggests that dietary intake is more relevant for human exposure to PCBs and PBDEs than living near the HWI	Tarragona, Spain	Hazardous Waste	1999	Longitudinal, Prospective	15	25-35	Female	7 samples - 7-10 km from HWI (urban); 8 samples - 4-8 km from HWI (petrochem)	Potentially. Residents pulled from urban area, areas near oil refineries, MWI. No known occupational exposure. Min residence 5 years.
185	Tajimi, M., Uehara, R., Watanabe, M., Oki, I., Ojima, T., and Nakamura, Y. 2005 Chemosphere Correlation coefficients between the dioxin levels in mother's milk and the distances to the nearest waste incinerator which was the largest source of dioxins from each mother's place of residence in Tokyo, Japan	BACKGROUND: To observe the relationship between the PCDD/F and Co-PCB levels in samples of human breast milk and nearby waste incinerators in Tokyo, Japan. METHODS: Breast milk was taken from 240 mothers residing in Tokyo, Japan to measure and analyze the concentrations of polychlorinated dibenzo-p-dioxins (PCDDs; 14 congeners), polychlorinated dibenzofurans (PCDFs; 15 congeners), and coplanar polychlorinated biphenyls (Co-PCBs; 12 congeners) contained in the fat. Individual milk samples (about 50 ml) were obtained from the mothers 30 days after delivery, between the months of June and September in 1999 and 2000. A map of Tokyo was used to measure the distances between each mother's place of residence and the closest public and industrial waste incinerators. RESULTS: The distances to the nearest waste incinerators bore no apparent correlations with the congeners of PCDD/Fs and Co-PCBs. The distances were also uncorrelated with the mean toxic equivalent quantities (TEQs) of PCDD/Fs (the sum of PCDDs and PCDFs), Co-PCBs, and the total PCDD/Fs and Co-PCBs. CONCLUSIONS: Although waste incinerators were the largest source of dioxins in Japan at the time of the study, the dioxins levels of mother's milk bore no apparent relationships with the distances between the mothers' domiciles and the nearest waste incinerators. In this study, several meaningful factors were not taken into account, namely, the wind direction, the level of dioxin emitted from each incinerator, the level of environmental pollution of dioxins, and the average time the mothers stayed at home each day. A full understanding of these points awaits future studies	Tokyo, Japan	Municipal and Industrial	Unspecified	Cross-Sectional, Prospective	240	25-34	Female	Women were selected at a range of 0-11 km from the incinerators.	Living at residence for more than 5 years

Source		*Control Group*					*Methods/Analytical Procedure*					*Results*				*Miscellaneous*	*Quality Assessment*				*Final Result*
Ref ID	**Citation**	**Number of Participants**	**Age of Participants**	**Sex of Participants**	**Location of Samples with respect to Incinerator**	**Prior Exposure to Chemicals**	**Study Duration**	**Was Lifestyle Questionnaire Provided to Participants?**	**Medium Sampled**	**Chemicals/Outcome Assessed**	**Analysis Method**	**Type of Statistical Analysis Performed**	**Sample Size**	**Correlation of Chemical Levels to Incinerator**	**Key Conclusions**	**Funding Source**	**Study Design**	**Study/Control Group Selection**	**Sample Collection**	**Critical Results Analysis**	**Include?**
169	Schuhmacher, M., Domingo, J. L., Hagberg, J., and Lindstrom, G. 2004 Chemosphere PCDD/F and non-ortho PCB concentrations in adipose tissue of individuals living in the vicinity of a hazardous waste incinerator	Baseline Study	N/A	N/A	N/A	N/A	4 years	Yes, to families.	Adipose Tissue	PCDD/F, non-ortho PCB	GC/MS	ANOVA	15	None identified.	Significant decreases noted for both mean and median values. No significant differences found between industrial and urban zones, though declines observed in both zones. Levels in women significantly higher than in men, likely due to higher total body fat levels in women.	Junta de Residus, Catalonia, Spain	Moderate	Moderate	High	Moderate	Yes
168	Schuhmacher, M., Domingo, J. L., Kiviranta, H., and Vartiainen, T. 2004 Chemosphere Monitoring dioxins and furans in a population living near a hazardous waste incinerator: levels in breast milk	Baseline Study	N/A	N/A	N/A	N/A	6 years	Yes	Breast Milk	PCDD/F	GC/MS	Mann-Whitney Test	15	None identified.	Significant decrease in median PCDD/F values observed between 1996 and 2002. Expected to be caused by reduced dietary intake of PCDD/Fs. No additional exposure from HWI observed.	Junta de Residus, Catalonia, Spain	Moderate	Moderate	High	High	Yes
170	Schuhmacher, M., Domingo, J. L., Llobet, J. M., Kiviranta, H., and Vartiainen, T. 1999 Chemosphere PCDD/F concentrations in milk of nonoccupationally exposed women living in southern Catalonia, Spain	N/A	N/A	N/A	N/A	N/A	1 year	Yes	Breast Milk	PCDD/F	GC	None	N/A	N/A	No significant differences between samples in urban downtown and industrial area. Levels similar or lower to previously reported values in other studies.	Junta de Residus, Catalonia, Spain	Moderate	Moderate	High	Moderate	Yes
163	Schuhmacher, M., Kiviranta, H., Vartiainen, T., and Domingo, J. L. 2007 Chemosphere Concentrations of polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) in milk of women from Catalonia, Spain	Baseline Study	N/A	N/A	N/A	N/A	6 years	Yes	Breast Milk	PCB, PBDE	GC/MS	Mann-Whitney Test	15	None identified.	Significant decrease in PCB levels between observed and baseline. No statistically significant difference between urban and industrial areas. No baseline data for PBDEs, though current levels are similar or lower than concentrations reported in recent studies.	Junta de Residus, Catalonia, Spain	Moderate	Moderate	High	High	Yes
185	Tajimi, M., Uehara, R., Watanabe, M., Oki, I., Ojima, T., and Nakamura, Y. 2005 Chemosphere Correlation coefficients between the dioxin levels in mother's milk and the distances to the nearest waste incinerator which was the largest source of dioxins from each mother's place of residence in Tokyo, Japan	There was no control group per se. However, women were selected between 0-11 km from the incinerators, so the further women could be considered as a control.	25-34	Female	Women were selected at a range of 0-11 km from the incinerators.	Living at residence for more than 5 years	2 years	Yes	Breast Milk	PCDD/F, co-planar PCB	GC/MS	Pearson product-moment correlation, multiple regression	240	None identified.	No significant correlations between mean TEQ's and distance from incinerator. Some correlations with individual congeners but all significant correlations were positive, indicating that levels fell as distance to incinerator shortened. Statistically significant correlations exist with age and history of delivery (first or second child).	Not specified.	Moderate	Moderate	High	Moderate	Yes

APPENDIX C-1B

Human Biomonitoring of Residents - Excluded

Source			Incinerator			Study Design	Study Group				
Ref ID	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
4	Agramunt, M. C., Schuhmacher, M., Hernandez, J. M., and Domingo, J. L. 2005 J.Expo.Anal.Environ.Epidemiol. Levels of dioxins and furans in plasma of nonoccupationally exposed subjects living near a hazardous waste incinerator	The potential adverse effects of hazardous waste incinerators (HWI) continue to be a subject of worry. The construction of the first and till now only HWI in Spain finished in 1999. To assess the potential impact of the plant on public health, a preoperational monitoring program was established during the period of construction. The main goal of the present study was to determine, after approximately 3 years of regular operations in the facility, the concentrations of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) in plasma of nonoccupationally exposed subjects living near the HWI. Blood samples were obtained from 20 volunteers aged 19-62 years. The mean PCDD/F concentration in plasma was 15.70 pg I-TEQ/g lipid (range 4.66-29.25 pg I-TEQ/g lipid), which is significantly lower than the mean level found in the baseline survey, 27.01 pg I-TEQ/g lipid (range 14.79-48.95 pg I-TEQ/g lipid). Reductions were noted for both sexes and for all age groups. The comparison with PCDD/F levels from a number of different countries shows that, in general terms, the current PCDD/F concentrations are lower than most results recently reported. It is concluded that emissions from the stack of the HWI assessed here should not mean any additional significant exposure to PCDD/Fs for the population living near the facility	Tarragona, Spain	Hazardous Waste	1998	Longitudinal, Prospective	20	19-62	Both, 50/50 split.	In vicinity.	Potentially. Residents pulled from urban area, areas near oil refineries, MWI. No known occupational exposure. Min residence 10 years.
9	Aozasa, O., Ohta, S., Nakao, T., Miyata, H., Mochizuki, A., Fujimine, Y., and Nomura, T. 2003 Bulletin of Environmental Contamination and Toxicology Monthly variation in blood dioxin level, characteristics of isomer composition, and isomer changes in residents near an incineration facility	None	Japan	Unspecified.	Unspecified	Longitudinal, Prospective	13	60-80	7 males, 6 females	Not specified.	Not specified.
32	Chen, H. L., Su, H. J., and Lee, C. C. 2006 Environ.Int. Patterns of serum PCDD/Fs affected by vegetarian regime and consumption of local food for residents living near municipal waste incinerators from Taiwan	The aim of this study was to evaluate possible factors affecting serum polychlorinated dibenzo-p-dioxin (PCDD) and dibenzofuran (PCDF) levels of people living near municipal waste incinerators (MWIs). We selected 19 MWIs in Taiwan and collected 1708 serum samples from residents 18-65 years old who had lived within 5 km of one of the selected MWIs for at least 5 years. The samples were analyzed using a standardized study protocol to assure comparability of the concentrations from 17 PCDD/F congeners. The results suggested that a vegetarian regimen was a protective factor to avoid serum PCDD/F accumulation in the subjects. In addition, the current data seemed to support the hypothesis that serum PCDD/F levels of residents living near MWIs are related to they consumed the locally grown or cultivated vegetable and animal foods, such as poultry products near the MWIs. Our results can be used to create guidelines for preventing excessive PCDD/F accumulation from eating animal and vegetable foods grown near MWIs	Nineteen incinerators in Taiwan	Municipal Waste	Not specified.	Cross-Sectional, Prospective	1708	18-65	~50/50 mix	Within 5 km of plant.	Residence minimum 5 years. No occupational exposure.
31	Chen, H. L., Su, H. J., Guo, Y. L., Liao, P. C., Hung, C. F., and Lee, C. C. 8-1-2006 Sci.Total Environ. Biochemistry examinations and health disorder evaluation of Taiwanese living near incinerators and with low serum PCDD/Fs levels	The main objective of this study was to establish background levels of serum PCDD/Fs and biochemistry of residents living near municipal waste incinerators (MWIs) which had been operating between 1 and 8 years, and also to examine the association between the serum PCDD/Fs levels and health outcomes of interest. Information on medical history, life-style, and dietary habits was obtained by questionnaire interview. Significantly elevated levels of glucose and blood urea nitrogen (BUN) were found in those with low to high serum PCDD/Fs levels ($p<0.05$), and PCDD/Fs levels were found to be positively associated with glucose levels, and marginally with GGT levels even after adjusting for age, sex, BMI and smoking status. Although no conclusive findings on health disorder were associated with the accumulation of serum PCDD/Fs in our study participants, we suggest that the current biochemistry examinations only reflect partially the physiological change in glucose modulation and liver function. However, the low serum PCDD/Fs level does not seem to be sufficient in eliciting pathological process for diabetes or liver-related diseases. The findings suggest that the human body's biochemistry functions such as liver and glucose modulation were affected by PCDD/Fs exposure at even these low serum PCDD/Fs levels found in the general population. Other biochemical functions therefore should be further analyzed, especially for hormone-related and immune functions	Twelve in Taiwan	Municipal Waste	~1998-2003	Cross-Sectional, Prospective	1034	18-65	50/50 mix	Within 5 km of plant.	Residence minimum 5 years. No occupational exposure.
44	Deml, E., Mangelsdorf, I., and Greim, H. 1996 Chemosphere Chlorinated dibenzodioxins and dibenzofurans (PCDD/F) in blood and human milk of non occupationally exposed persons living in the vicinity of a municipal waste incinerator	The concentrations of chlorinated dibenzodioxins and dibenzofurans (PCDD/F) in human blood and in milk from non-occupationally exposed persons living in the vicinity of a municipal waste incinerator were determined. As compared to background levels in the general population in Germany the results give no indication of an enhanced body burden of PCDD/F. This is in agreement with earlier investigations in the same area, showing normal background concentrations in soil, fruit and vegetables. In conclusion, no direct health hazard related to PCDD/F-emissions from a local municipal waste incinerator may be expected	Schwandorf, Germany	Municipal Solid Waste	1983	Cross-Sectional, Prospective	46	Unspecified.	19 men; 27 women.	38 within 5.5 km; 4 within 9-14 km; 4 not known.	43 living in Schwandorf 7 years prior, remaining 3 5 years prior.

Source		Control Group					Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Citation	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Study Duration	Was Lifestyle Questionnaire Provided to Participants?	Medium Sampled	Chemicals/Outcome Assessed	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
4	Agramunt, M. C., Schuhmacher, M., Hernandez, J. M., and Domingo, J. L. 2005 J.Expo.Anal.Environ.Epidemiol. Levels of dioxins and furans in plasma of nonoccupationally exposed subjects living near a hazardous waste incinerator	Previous baseline.	N/A	N/A	N/A	N/A	5 years	No	Blood Plasma	PCDD/F	GC/MS	Kruskal-Wallis, Mann-Whitney	20	None identified.	Statistically significant reduction of mean PCDD/F levels observed with respect to previous studies.	Junta de Residus, Catalonia, Spain	Moderate	Moderate	Low	Moderate	No
9	Aozasa, O., Ohta, S., Nakao, T., Miyata, H., Mochizuki, A., Fujimine, Y., and Nomura, T. 2003 Bulletin of Environmental Contamination and Toxicology Monthly variation in blood dioxin level, characteristics of isomer composition, and isomer changes in residents near an incineration facility	N/A	N/A	N/A	N/A	N/A	1 year	No	Blood	PCDD/F, PCB	GC/MS	Coefficient of variation.	13	None identified by authors.	Levels observed were generally higher than "control" levels from previous reports. Isomer composition analyses show similar composition when comparing study group to "general population". Large amount of variation over the course of 7 months in three patients indicates necessity to measure levels several times instead of once. Blood sampling could be reduced to analysis of 5-8 key isomers, allowing for more sampling to occur in studies.	Not specified.	Low	Low	Low	Low	No
32	Chen, H. L., Su, H. J., and Lee, C. C. 2006 Environ.Int. Patterns of serum PCDD/Fs affected by vegetarian regime and consumption of local food for residents living near municipal waste incinerators from Taiwan	No control group.	N/A	N/A	N/A	N/A	5 years	Yes	Blood	PCDD/F	GC/MS	Chi-square test, multiple regression analysis.	1708	None identified by authors.	PCDD/F levels did not differ from findings in previously published Spanish reports. Lower than previously published Belgian values. Serum levels in non-vegetarians significantly higher than in vegetarians. Values significantly higher in those who ate locally produced foods. Supports hypothesis that serum influenced more by dietary intake than by incineration.	Taiwan Environmental Protection Administration	Low	Moderate	High	Moderate	No
31	Chen, H. L., Su, H. J., Guo, Y. L., Liao, P. C., Hung, C. F., and Lee, C. C. 8-1-2006 Sci.Total Environ. Biochemistry examinations and health disorder evaluation of Taiwanese living near incinerators and with low serum PCDD/Fs levels	No control group.	N/A	N/A	N/A	N/A	2 years	Yes	Blood	PCDD/F, Biochemical Parameters	GC/MS	t-test, ANOVA	1034	None identified by authors.	Sex and age were associated with distribution of serum PCDD/Fs. Glucose and GGT levels were associated with PCDD/F levels. No significant association to offer convincing evidence for PCDD/F exposure and health effects.	Taiwan Environmental Protection Administration	Low	Moderate	High	Moderate	No
44	Deml, E., Mangelsdorf, I., and Greim, H. 1996 Chemosphere Chlorinated dibenzodioxins and dibenzofurans (PCDD/F) in blood and human milk of non occupationally exposed persons living in the vicinity of a municipal waste incinerator	No control group.	N/A	N/A	N/A	N/A	1 year	Yes	Blood, Breast Milk	PCDD/F	GC/MS	None	N/A	None identified.	No enhanced body burden indicated by results of the present study. Values are in the range of background levels found in Germany. No signficant difference between levels in gender, age, or life habit.	Not specified.	Low	Low	Moderate	Low	No

Source			Incinerator			Study Design	Study Group				
Ref ID	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
67	Gonzalez, C. A., Kogevinas, M., Gadea, E., Huici, A., Bosch, A., Bleda, M. J., and Papke, O. 2000 Arch.Environ.Health Biomonitoring study of people living near or working at a municipal solid-waste incinerator before and after two years of operation	The authors conducted a biomonitoring study in the town of Mataro, Spain, of 104 subjects who lived near (i.e., within 0.5-1.5 km) an incinerator, 97 subjects who lived far (i.e., within 3.5 km-4.0 km) from an incinerator, and 17 workers at a new municipal solid-waste incinerator. The study commenced before the incinerator started functioning in 1995, and 2 y later (1977) the authors undertook the final part of the study. Dioxins, furans, and polychlorinated biphenyls were studied in pooled blood samples (n = 22), and individual blood and urine samples were analyzed for the detection of lead, chromium, cadmium, and mercury. In 1995, dioxin blood levels were low-both among those living close to the incinerator (mean = 13.5 ng international-dioxin toxic equivalents/kg fat) and among those living far away (mean = 13.4 ng international-dioxin toxic equivalents/kg fat). In 1997, dioxin and polychlorinated biphenyl levels had increased in both groups of residents by approximately 25% and 12%, respectively. (The increase in dioxin levels was about 10% when the authors took into account the mean of two repeated quality-control analyses.) Blood lead levels decreased, but no difference was observed for chromium, cadmium, and mercury. Minimal changes were seen among workers. Given the low dioxin stack emissions from this plant (mean = 2.5-0.98 ng international-dioxin toxic equivalents/m3) and that the blood dioxin levels did not depend on distance of residence from the incinerator, it would appear unlikely that the small increase in dioxin blood levels resulted from the incinerator's emissions	Mataro, Spain	Municipal Solid Waste	1995	Longitudinal, Prospective	104/17 workers	18-69	Both	Within 0.5-1.5 km or working at the facility.	Not specified.
68	Gonzalez, C. A., Kogevinas, M., Gadea, E., Pera, G., and Papke, O. 2001 Epidemiology Increase of dioxin blood levels over the last 4 years in the general population in Spain	None	Mataro, Spain	Municipal Solid Waste	1996	Longitudinal, Prospective	104	18-69	Both	Within 1.5 km of facility	Not specified.
69	Granero, S., Llobet, J. M., Schuhmacher, M., Corbella, J., and Domingo, J. L. 1998 Trace Elements and Electrocytes Biological monitoring of environmental pollution and human exposure to metals in Tarragona, Spain. I. Levels in hair of school children	Hair samples of 124 school children (11-13 years old) living in 3 residential areas in the neighborhood of a hazardous waste incinerator (HWI) now under construction (Tarragona, Spain) were analyzed for arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), mercury (HE), manganese (Mn), nickel (Ni), lead (Pb), tin (Sn), thallium (Tl), and vanadium (V) concentrations by ICP-MS. Beryllium, Tl, and V levels were under the respective detection limits. The concentrations (mug/g) of the remaining 8 elements showed the following ranges: 0.01 - 0.10 for As, 0.03 - 0.73 for Cd, 0.13 - 3.23 for Cr, 0.09 - 2.54 for Hg, 0.04 - 0.99 for Mn, 0.10 - 3.18 for Ni, 0.38 - 23.83 for Pb, and 0.01 - 2.80 for Sn. No differences in relation to sex were observed. By contrast, significant differences with respect to the place of residence were found in the hair concentrations of As, Cd, Cr, Hg, and Sn. In general terms, the current metal levels in hair of school children are of the same order of magnitude or even lower than reference values for these elements. These results will be useful for future assessments of the impact of metal emissions from the new HWI on public health	Tarragona, Spain	Hazardous Waste	1999	Cross-Sectional, Prospective	124	11-13	55 male, 69 female	N/A	Potentially. Some children from areas with MWI, oil refineries.
78	Huang, H. Y., Jeng, T. Y., Lin, Y. C., Ma, Y. C., Kuo, C. P., and Sung, F. C. 2007 Inhal.Toxicol. Serum dioxin levels in residents living in the vicinity of municipal waste incinerators in Taiwan	This study used data obtained from the Taiwan Environmental Protection Administration to measure the dioxin exposure and the body burden for residents living in the vicinity of 19 municipal waste incinerators (MWIs). A survey was conducted in 1999-2003 for the residents. Approximately 16 ambient air samples and a 60-ml blood samples of 84 to 92 residents aged 18-65 yr were collected randomly in four zones (A, B, C, D) for each MWI site based on the atmospheric dispersion model (ADM). Zone A was defined with the highest pollution level, followed by zones B and C, and zone D (background level). Congeners of 17 polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) were determined for each sample. We summarized the PCDD/Fs levels in air samples and serum specimens by zone for these 19 sites. The mean ambient levels of PCDD/Fs fitted the ADM, the highest from zone A and the lowest from zone D (2.74 vs. 0.13 pg I-TEQ/Nm3). However, the mean serum concentration in zones A was not distinct from that in zones D (18.7 vs. 19.0 pg WHO-TEQ/g lipid). The age-specific average serum concentration increased from 13.27 pg WHO-TEQ/g in 18- to 25-yr-old subjects to 23.46 pg WHO-TEQ/g lipid in 56- to 65-yr-old subjects. In conclusion, the serum PCDD/Fs levels among residents did not adhere to the dispersion model for incineration emissions. The dose-response of serum PCDD/Fs by age suggests that the body burden of the chemicals is mainly associated with other sources instead of with inhalation	Nineteen municipalities, Taiwan	Municipal Solid Waste	Varying-2004	Cross-Sectional, Prospective	1213	18-65	Both	Reside within 5 km. 3 target zones identified by Gaussian atmospheric dispersion model as affected emission exposure zones.	Minimum residence 5 years.

Source		Control Group					Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Citation	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Study Duration	Was Lifestyle Questionnaire Provided to Participants?	Medium Sampled	Chemicals/Outcome Assessed	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
67	Gonzalez, C. A., Kogevinas, M., Gadea, E., Huici, A., Bosch, A., Bleda, M. J., and Papke, O. 2000 Arch.Environ.Health Biomonitoring study of people living near or working at a municipal solid-waste incinerator before and after two years of operation	97	18-69	Both	At least 3-4km from plant.	Not specified.	3 years	Yes	Blood, Urine	PCDD/F, PCB, Pb, Cd, Hg, Cr	GC/MS for PCDD/F, PCB; AAS/Hydride Generation for Metals	Kruskal-Wallis test	Varied based on test.	None identified.	Blood levels of PCDD/F are low. Over 2 years, small increase in occurred, but independent of location of residence. Further follow-up required, as 2 years deemed not enough to detect longer-term changes. Similar results for PCBs. Pb levels decreased, and other metals stable.	Not specified.	High	Moderate	High	Low	No
68	Gonzalez, C. A., Kogevinas, M., Gadea, E., Pera, G., and Papke, O. 2001 Epidemiology Increase of dioxin blood levels over the last 4 years in the general population in Spain	97	18-69	Both	At least 4 km from facility.	Not specified.	5 years	Yes	Blood	PCDD	Same as baseline.	None	N/A	None identified.	Again, blood levels of PCDD/F increased in all tested populations - independent of location, sex and age. Trend could be result of increase of exposure to dioxins in food or other unidentified sources.	Not specified.	High	Moderate	High	Low	No
69	Granero, S., Llobet, J. M., Schuhmacher, M., Corbella, J., and Domingo, J. L. 1998 Trace Elements and Electrocytes Biological monitoring of environmental pollution and human exposure to metals in Tarragona, Spain. I. Levels in hair of school children	Baseline Study	N/A	N/A	N/A	N/A	1 year	No	Hair cut from area close to occipital region of scalp.	As, Be, Cd, Cr, Hg, Mn, Ni, Pb, Sn, Tl, V	ICP/MS and Hydride Generation	ANOVA	Varied based on test.	No correlation - baseline study.	No relationship between sex and metal levels in hair with the exception of As. Levels of As and Cr significantly higher in children living near industrial complex. Cd, Hg, and Sn higher in urban children.	Department of Environment, Catalonia	Moderate	Moderate	Low	High	No
78	Huang, H. Y., Jeng, T. Y., Lin, Y. C., Ma, Y. C., Kuo, C. P., and Sung, F. C. 2007 Inhal.Toxicol. Serum dioxin levels in residents living in the vicinity of municipal waste incinerators in Taiwan	445	18-65	Both	Background zone, unaffected by emissions as determined by Gaussian atmospheric dispersion model.	Minimum residence 5 years.	4 years	Yes	Blood	PCDD/F	GC/MS	ANOVA, Pearson's Correlation	1658	None identified.	Overall average PCDD/F levels at the median level among international levels. Observed ambient air concentrations confirm ability of atmospheric model to predict impact zones. No significant association of PCDD/F levels with chemicals in the air, the distance between houses and incinerator or years living in any of the zones. Similarly increasing PCDD/F concentrations with age in all zones, including background. This suggests a lifetime accumulation of chemicals taken in from other sources. Intake from inhalation of MWI emissions not large enough to affect body burden.	Not specified.	Moderate	Moderate	High	Low	No

Source			Incinerator			Study Design	Study Group				
Ref ID	**Citation**	**Abstract**	**Location of Incinerator**	**Type of Incinerator**	**Operation Start Date**	**Study type**	**Number of Participants**	**Age of Participants**	**Sex of Participants**	**Location of Samples with respect to Incinerator**	**Prior Exposure to Chemicals**
84	Kim, B. H., Ikonomou, M. G., Lee, S. J., Kim, H. S., and Chang, Y. S. 1-5-2005 Sci.Total Environ. Concentrations of polybrominated diphenyl ethers, polychlorinated dibenzo-p-dioxins and dibenzofurans, and polychlorinated biphenyls in human blood samples from Korea	Analysis of blood samples is an effective way of evaluating contamination by persistent pollutants such as polybrominated diphenyl ethers (PBDEs), polychlorinated dibenzo-p-dioxin/furans (PCDD/Fs), and polychlorinated biphenyls (PCBs) in human population. Concentrations of PBDEs, PCDD/Fs and PCBs were measured in the blood of laborers (n = 13) working full time in two different municipal waste incinerator (MWI) plants and residents from the general population (n = 22) living in areas near MWIs in Korea. The concentrations of PBDEs were found to be slightly higher in the blood of incineration workers (8.61-46.05 ng/g lipid; mean, 19.33 ng/g lipid; median, 15.94 ng/g lipid) in comparison to that of residents from the general population (7.24-28.89 ng/g lipid; mean, 15.06 ng/g lipid; median, 14.34 ng/g lipid). The total average PCDD/Fs and PCB TEQ concentration was 20.11 pg/g lipid, averaged over incineration workers (17.73 pg/g lipid) and the general population (21.52 pg/g lipid). In addition, the average total crude concentration of PCDD/Fs was 7.40 ng/g lipids, which was 4.1 times greater than for PBDEs. Congener specific analysis confirmed that BDE 47 was a predictive indicator for total PBDE concentration (correlation coefficient r = 0.912), and that PCB 153 was a predictive indicator for total PCB concentration (r = 0.967). The PBDE levels in human blood in Korea are much higher than those reported in other countries. The presence of the BDE 183 congener was characteristic in the blood of workers from an electronic dismantling facility in MWIs	Seoul, Korea	Municipal Solid Waste	Not specified.	Cross-Sectional, Prospective	13 workers; 22 residents	21-63	All workers male; Residents: 10 men, 12 women.	Reside within 5 km.	No occupational exposure for residents. Lived within 5km for min. 5 years.
98	Leem, J. H., Hong, Y. C., Lee, K. H., Kwon, H. J., Chang, Y. S., and Jang, J. Y. 2003 Ind.Health Health survey on workers and residents near the municipal waste and industrial waste incinerators in Korea	Hazardous substances, such as polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) also have been detected in Municipal Solid Waste (MSW) and industrial waste incinerators in Korea. In this study, we estimated the exposure status of these hazardous substances and their heath effects in workers and residents near the MSW incinerators and residents near the industrial waste incinerators. We interviewed 13 workers and 16 residents from the area around the two MSW incinerators, and further 10 residents from the area around one industrial waste incinerator, which is suspected to emit higher hazardous substances. During the interview we collected information including sociodemographic information, personal habits, work history, detailed gynecologic and other medical history. Blood samples from 45 subjects were also collected for analysis of PCDDs and PCDFs, which were analyzed by HRGC-HRMS (High Resolution Gas Chromatography-High Resolution Mass Spectrometer). In addition to a questionnaire survey, urinary concentrations of 8-hydroxydeoxyguanosine (8-OH-dG) and malondialdehyde (MDA) were measured as oxidative injury biomarkers. Urinary concentrations of 8-OH-dG were determined by in vitro ELISA (JAICA, Fukuroi, Japan). MDA were determined by HPLC using adduct with TBA (thiobarbituric acid). The PCDD/F concentrations in residents from the area around industrial waste incinerator were higher than those in workers and residents from the area around MSW incinerator. The average toxic equivalency (TEQ) concentrations of PCDD/Fs in residents from the area around industrial waste incinerator were 53.4 pg I-TEQs/g lipid. The average TEQ concentrations of PCDD/Fs in	Seoul and Pyongtack, Korea	Municipal Solid Waste; Industrial Waste	Not specified.	Cross-Sectional, Prospective	13 workers; 26 residents	Unspecified.	Unspecified	Residence within 1.5 km.	Residence minimum 1 year.
121	Moon, C. S., Chang, Y. S., Kim, B. H., Shin, D., and Ikeda, M. 2005 International Archives of Occupational and Environmental Health Evaluation of serum dioxin congeners among residents near continuously burning municipal solid waste incinerators in Korea	The objective of this study was to evaluate the congeners of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in Korean serum samples as biological markers. Serum samples from 103 participants were analyzed. Participants consisted of 28 workers in municipal solid waste incinerators (MSWIs), and 21 men and 54 women who had lived for at least 3 years prior to 2002 in areas within 300 m of incinerators in large Korean cities. Serum samples were analyzed for 17 PCDD/PCDFs congeners by high resolution gas chromatography-high resolution mass spectrometry. Geometric mean (GM) PCDD/PCDF levels in the serum samples were 3.14, 8.04, 6.12 and 6.60 pg TEQ/g lipid for workers, male residents, female residents and the sum of male and female residents, respectively. The GM PCDD/PCDF level in the serum of workers was not significantly different from the values for residents near MSWIs. In the 75 participants who resided near MSWIs, the congeners that most contributed to the total TEQ were 1,2,3,6,7,8-hexachlorodibenzofuran (1,6-HxCDF), 2,3,4,7,8-pentachlorodibenzofuran (4-PeCDF), 1,2,3,4,6,7,8-heptachlorodibenzofuran (1,4,6-HpCDF), 1,2,3,7,8,9-hexachlorodibenzofuran (1,9-HxCDF), 1,2,3,4,7,8-hexachlorodibenzo-p-dioxin (1,4-HxCDD), 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin (1,6-HxCDD). In the workers, the congeners that made the greatest contribution were 1,6-HxCDD, 4-PeCDF,	Large Cities in Korea	Municipal Solid Waste	Not specified.	Cross-Sectional, Prospective	28 workers; 75 residents	21-64	All workers male; Residents: 21 men, 54 women.	Reside within 300 m.	No occupational exposure for residents. Residence for min. 3 years prior to 2002.
126	Nadal, M., Perello, G., Schuhmacher, M., Cid, J., and Domingo, J. L. 8-18-2008 Chemosphere Concentrations of PCDD/PCDFs in plasma of subjects living in the vicinity of a hazardous waste incinerator: Follow-up and modeling validation	In 2007, the concentrations of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDFs) were determined in plasma of non-occupationally exposed subjects living near the only hazardous waste incinerator (HWI) in Spain (Constanti, Tarragona County, Catalonia). These data were compared with the levels found in two previous surveys performed in 1998 (baseline) and 2002. The current mean PCDD/PCDF concentration in plasma was 9.36pg I-TEQg(-1) of lipid (range: 1.76-23.44pg I-TEQg(-1) of lipid). It means a significant reduction of the mean PCDD/PCDFs levels in plasma in comparison to the concentrations found in 1998 and 2002 (27.01 and 15.70pg I-TEQg(-1) of lipid, respectively). This important decrease agrees well with the notable reduction in the dietary intake of PCDD/PCDFs recently noted for the population of the same area (210.1pg I-TEQd(-1), 63.8pgWHO-TEQd(-1), and 27.8pgWHO-TEQd(-1), in 1998, 2002 and 2007, respectively). The current data were also used to predict theoretical PCDD/PCDF concentrations in plasma by executing a single-compartment empirically-based pharmacokinetic model on the basis of the daily intake of these pollutants by the local population	Tarragona, Spain	Hazardous Waste	1999	Longitudinal, Prospective	20	17-61	Both, 50/50 split.	In vicinity.	Potentially. Residents pulled from urban area, areas near oil refineries, MWI. No known occupational exposure. Min residence 10 years.
164	Schuhmacher, M., Domingo, J. L., Llobet, J. M., Lindstrom, G., and Wingfors, H. 1999 Chemosphere Dioxin and dibenzofuran concentrations in blood of a general population from Tarragona, Spain	The concentrations of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) were determined in plasma samples of 20 nonoccupationally exposed subjects living in the vicinity of a new hazardous waste incinerator (HWI), now under construction in Tarragona (Catalonia, Spain). The mean PCDD/F value was 27.0 pg I-TEQ/g lipid with a range from 14.8 to 48.9 pg I-TEQ/g lipid. All samples showed higher PCDD than PCDF levels. Although PCDD/F concentrations were higher in women (27.7 pg I-TEQ/g lipid) than in men (25.2 pg I-TEQ/g lipid), the difference was not statistically significant. While a significant correlation (r = 0.565, p < 0.01) between the age of the subjects and the levels of PCDD/F in plasma could be observed, no significant differences were found in relation to the specific residential area. The plasma concentrations of PCDD/F obtained in the current study are discussed and compared with the results of similar investigations reported in the last two years	Tarragona, Spain	Hazardous Waste	1997	Longitudinal, Prospective	20	28-62	13 male, 7 female	Some near incinerator, others near other industry, others in urban downtown.	Potentially. Residents pulled from urban area, areas near oil refineries, MWI. No known occupational exposure. Min residence 10 years.

Source		Control Group					Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Citation	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Study Duration	Was Lifestyle Questionnaire Provided to Participants?	Medium Sampled	Chemicals/Outcome Assessed	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
84	Kim, B. H., Ikonomou, M. G., Lee, S. J., Kim, H. S., and Chang, Y. S. 1-5-2005 Sci.Total Environ. Concentrations of polybrominated diphenyl ethers, polychlorinated dibenzo-p-dioxins and dibenzofurans, and polychlorinated biphenyls in human blood samples from Korea	No control group.	N/A	N/A	N/A	N/A	1 year	No	Blood	PBDE, PCDD/F, PCB	GC/MS	t-test, PCA	35	Positive correlation for PBDE in workers v. residents. No correlation for PCDD/F, PCB.	PBDE significantly higher in workers versus nearby residents. No correlation of PBDE with age, BMI - conclusion that exposure is coming from workplace. PCDD/F, PCB levels significantly higher in residents versus workers. Correlation observed between PCDD/F and age, but not BMI. No statistical difference between levels in men and women. No statistical difference between levels in smokers and non-smokers. Further studies on a larger number of individuals required.	Ministry of Environment, Korea	Very Low	Low	Moderate	Moderate	No
98	Leem, J. H., Hong, Y. C., Lee, K. H., Kwon, H. J., Chang, Y. S., and Jang, J. Y. 2003 Ind.Health Health survey on workers and residents near the municipal waste and industrial waste incinerators in Korea	No control group.	N/A	N/A	N/A	N/A	Not specified.	Yes	Blood	PCDD/F	GC/MS	Mann-Whitney Test	39	Higher levels at less regulated industrial waste incinerator compared to municipal waste incinerator.	No significant difference between residents and workers at MWI. PCDD/F levels within WHO background level. IWI PCDD/F level higher than WHO background level. Levels significantly higher in residents near IWI compared to MWI. Likely due to emissions regulations allowing for much higher levels to be emitted out of IWI, and significantly older population near IWI.	Not specified.	Low	Moderate	Moderate	Moderate	No
121	Moon, C. S., Chang, Y. S., Kim, B. H., Shin, D., and Ikeda, M. 2005 International Archives of Occupational and Environmental Health Evaluation of serum dioxin congeners among residents near continuously burning municipal solid waste incinerators in Korea	No control group.	N/A	N/A	N/A	N/A	2 years	No	Blood	PCDD/F	GC/MS	ANOVA, Scheffe's Test	103	None identified.	Significant difference in PCDD/F levels observed between male workers and male residents (higher in residents). Difference not observed with female residents. Some statistical differences observed within individual congeners. No additional exposure to PCDD/Fs for workers.	Korea Science and Engineering Foundation	Low	Low	Low	Moderate	No
126	Nadal, M., Perello, G., Schuhmacher, M., Cid, J., and Domingo, J. L. 8-18-2008 Chemosphere Concentrations of PCDD/PCDFs in plasma of subjects living in the vicinity of a hazardous waste incinerator: Follow-up and modeling validation	Previous baseline and 3 year follow up study.	N/A	N/A	N/A	N/A	8 years	No	Plasma	PCDD/F	GC/MS	Kruskal-Wallis test/ANOVA	20	None identified.	Statistically significant reduction of mean PCDD/F levels observed with respect to previous studies.	Agencia Catalana de Residus, Catalonia, Spain	Moderate	Moderate	Low	Moderate	No
164	Schuhmacher, M., Domingo, J. L., Llobet, J. M., Lindstrom, G., and Wingfors, H. 1999 Chemosphere Dioxin and dibenzofuran concentrations in blood of a general population from Tarragona, Spain	N/A - baseline study	N/A	N/A	N/A	N/A	1 year	No	Blood Plasma	PCDD/F	GC/MS	ANOVA	20	N/A	Baseline levels do not pose a health hazard to the population. No statistically significant differences in levels based on sex or living area.	Department of Environment, Catalonia	Moderate	Moderate	Low	Moderate	No

APPENDIX C-2A

Human Biomonitoring of Facility Employees - Included

Source			Incinerator			Study Design	Study Group				
Ref ID	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
5	Agramunt, M. C., Domingo, A., Domingo, J. L., and Corbella, J. 2003 Toxicology Letters Monitoring internal exposure to metals and organic substances in workers at a hazardous waste incinerator after 3 years of operation	The potential adverse effects of hazardous waste incinerators (HWI) continue to be a subject of worry. The construction of the first and up till now only HWI in Spain finished in 1999. Twenty-six subjects employed at this HWI were divided into three groups: plant, laboratory and administration. Plasma analyses of HCB, PCBs (28, 52, 101, 138, 153 and 180), and PCDD/Fs, as well as urinary analyses of 2,4- and 2,5-dichlorophenol (DCPs), 2,4,5- and 2,4,6-trichlorophenol (TCPs), pentachlorophenol (PCP), and 1-hydroxypyrene (1-HP) were carried out. Blood concentrations of Be, Mn, Hg and Pb, and urinary levels of Cd, Cr, Ni and V were also determined. In plant workers, the current levels of organic substances and metals in blood and urine did not show any increase for any of the compounds analysed (excepting urinary V). By contrast, plasma levels of PCDD/Fs and PCBs 28, 52, 101, 138 and 153 were significantly lower than the respective baseline concentrations. The current chlorophenol concentrations in urine were similar or lower than the baseline levels, with the exception of 2,5-DCP that showed a significant increase. The concentrations of organic and inorganic substances found in this study do not differ from those corresponding to non-occupationally exposed subjects.	Constanti, Spain	Hazardous Waste Incinerator	1999	Longitudinal, Prospective	26	24-38	19 men, 7 women	Workers	3 years of employment at the incinerator, either as an operations, laboratory, or management worker.
29	Chao, C. L. and Hwang, K. C. 2005 Journal of Postgraduate Medicine Arsenic burden survey among refuse incinerator workers	BACKGROUND: Incinerator workers are not considered to have arsenic overexposure although they have the risk of overexposure to other heavy metals. AIM: To examine the relationship between arsenic burden and risk of occupational exposure in employees working at a municipal refuse incinerator by determining the concentrations of arsenic in the blood and urine. SETTINGS AND DESIGN: The workers were divided into three groups based on their probability of contact with combustion-generated residues, namely Group 1: indirect contact, Group 2: direct contact and Group 3: no contact. Healthy age- and sex-matched residents living in the vicinity were enrolled as the control group. MATERIALS AND METHODS: Heavy metal concentrations were measured by atomic absorption spectrophotometer. Downstream rivers and drinking water of the residents were examined for environmental arsenic pollution. A questionnaire survey concerning the contact history of arsenic was simultaneously conducted. STATISTICAL ANALYSIS: Non-parametric tests, cross-tabulation and multinomial logistic regression. RESULTS: This study recruited 122 incinerator workers. The urine and blood arsenic concentrations as well as incidences of overexposure were significantly higher in the workers than in control subjects. The workers who had indirect or no contact with combustion-generated residues had significantly higher blood arsenic level. Arsenic contact history could not explain the difference. Airborne and waterborne arsenic pollution were not detected. CONCLUSION: Incinerator workers run the risk of being exposed to arsenic pollution, especially those who have incomplete protection in the workplace even though they only have indirect or no contact with combustion-generated pollutants	Taipei City, Taiwan	Municipal Solid Waste	1995	Cross Sectional	122	26-60	105 males; 17 females	Workers - Various positions with varying exposure levels (Group 1 - indriect exposure, Group 2 - direct exposure, Group 3 - No Exposure)	Mean Employment duration 3 months - 16 years.
50	Domingo, J. L., Schuhmacher, M., Agramunt, M. C., Muller, L., and Neugebauer, F. 2001 Int.Arch.Occup.Environ.Health Levels of metals and organic substances in blood and urine of workers at a new hazardous waste incinerator	OBJECTIVE: To assess baseline concentrations of a number of metals and organic compounds in blood and urine of 28 workers employed at a new hazardous waste incinerator (HWI), before operation of the plant. METHODS: Plasma analyses of hexachlorobenzene (HCB), polychlorinated biphenyls (PCB 28, 52, 101, 138, 153 and 180), benzene, toluene, ethylbenzene, m-xylene, and polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) were carried out. The urinary levels of 2,4- and 2,5-dichlorophenol (DCPs), 2,4,5- and 2,4,6-trichlorophenol (TCPs) and pentachlorophenol (PCP), as well as those of 1-hydroxypyrene (1-HP) were also measured. Beryllium (Be), manganese (Mn), mercury (Hg) and lead (Pb) concentrations were determined in total blood, while the levels of arsenic (As), cadmium (Cd), chromium (Cr), nickel (Ni) and vanadium (V) were measured in urine. RESULTS: The levels of benzene, toluene, ethylbenzene and m-xylene were under their respective detection limits. The concentrations of HCB, PCBs and PCDD/Fs in plasma of the HWI workers, chlorophenols (CLPs) and 1-HP urinary concentrations, as well as those of metals in blood and urine are shown. PCDD/F concentrations in plasma of the new HWI workers ranged between 13.4 and 84.0 pg international toxic equivalents (I-TEQ)/g lipid, with a geometric mean value of 24.4 pg I-TEQ/g lipid. DISCUSSION: PCDD/F levels, as well as the concentrations of PCBs were of the same order of magnitude as those recently obtained for non-occupationally exposed populations of Catalonia (Spain). No significant gender differences were found for the levels of HCB, PCBs and PCDD/Fs. Although the present results showed a notable variability in the levels of CLPs, geometric mean values of these compounds were similar or even lower than those considered as potential reference values. Metal concentrations in blood and urine were also of the same order of magnitude than previously reported metal levels in the same area. CONCLUSION: The present results should be useful in future surveys in which internal exposure of the HWI workers will be determined	Constanti, Spain	Hazardous Waste Incinerator	1999	Cross-Sectional, Prospective, Baseline Study	28	23-58	22 men, 6 women	Workers	No Previous Occupational Exposure - Incinerator Not Operational Yet
93	Kumagai, S., Koda, S., Miyakita, T., Yamaguchi, H., Katagi, K., and Yasuda, N. 2000 Occupational and Environmental Medicine Polychlorinated dibenzo-p-dioxin and dibenzofuran concentrations in the serum samples of workers at continuously burning municipal waste incinerators in Japan	OBJECTIVES: To find whether concentrations of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in serum increased in workers at municipal incinerators that burn continuously. METHODS: 30 Workers employed at three municipal waste incineration plants (incinerator workers) and 30 control workers were studied. The incinerator workers had worn dust masks or airline masks during the periodic repair work inside the incinerators. Previous job, dietary habit, smoking habit, distance from residence to the incineration plant, and body weight and height were obtained from a questionnaire survey. Concentrations of PCDDs/PCDFs were measured in the serum of the workers and the dust deposited in the plants. The influence of various factors on serum concentrations of PCDDs/PCDFs was examined by multiple regression analysis. RESULTS: Dust analysis showed the greatest amount of octachlorodibenzo-p-dioxin (OCDD), followed by 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin (HpCDD), 1,2,3,4,6,7,8-heptachlorodibenzofuran (HpCDF), and octachlorodibenzofuran (OCDF). The toxicity equivalents (TEQs) of PCDDs and PCDFs in the deposited dust were 4.8, 1.0, and 6.4 ng TEQs/g, respectively, for plants A, B, and C. The mean serum TEQs of PCDDs and PCDFs in the incinerator workers and control workers were 19.2 and 22.9 pg TEQs/g lipid, respectively, for area A, 28.8 and 24.5 pg TEQs/g lipid for area B, and 23.4 and 23.6 pg TEQs/g lipid for area C. No significant differences were found between the incinerator workers and the controls for TEQs of PCDDs and PCDFs separately, and TEQs of PCDDs and PCDFs together. However, the serum 1,2,3,4,6,7,8-HpCDF concentration was significantly higher in the incinerator workers than in the controls for all the three areas. When the exposure index to 1,2,3,4,6,7,8-HpCDF is defined as the product of the concentration of 1,2,3,4,6,7,8-HpCDF in the deposited dust and duration of employment, the concentration of 1,2,3,4,6,7,8-HpCDF in serum increased as the exposure index increased. Multivariate analysis suggested that the serum concentration of HpCDF increased with duration of employment at the incineration plants and OCDF increased with employment of > or = 21 years. The other significant variables ($p < 0.01$ or $p < 0.001$) were area for hexachlorodibenzo-p-dioxin (HxCDD) and tetrachlorodibenzofuran (TCDF), Brinkman index for HpCDD, and body mass index (BMI) for tetrachlorodibenzo-p-dioxin (TCDD), HpCDD, and TEQs of PCDDs. CONCLUSION: The serum TEQs of PCDDs and PCDFs was not significantly higher among the incinerator workers, but the serum concentration of 1,2,3,4,6,7,8-HpCDF was. This suggests that the incinerator workers had inhaled dust containing PCDDs and PCDFs while working in plants equipped with incinerators that burn continuously	Fukuoka, Kochi and Osaka prefectures, Japan	3 municipal waste incinerators	Not specified.	Cross-sectional, prospective	30	40-59	Not specified.	Workers - Various positions	Mean employment term 22-24.5 years

Source		Control Group					Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Citation	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Study Duration	Was Lifestyle Questionnaire Provided to Participants?	Medium Sampled	Chemicals/ Outcome Assessed	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
5	Agramunt, M. C., Domingo, A., Domingo, J. L., and Corbella, J. 2003 Toxicology Letters Monitoring internal exposure to metals and organic substances in workers at a hazardous waste incinerator after 3 years of operation	28	23-58	22 men, 6 women	Workers	No Previous Occupational Exposure - Incinerator Not Operational Yet	4 years	Yes	Blood, Urine	PCDD/F, PCB, HCB, Be, Mn, Hg, Pb, Cd, Cr, Ni, V, DCP, TCP, PCP, 1-HP	Organics: GC/MS; Metals: ICP/MS;	Kruskal-Wallis, Mann-Whitney	26	None identified.	After 3 years of regular operation, no evident signs of internal exposure to a number of inorganic and organic substances were found. Most concentrations were similar or lower than baseline levels. Notable reduction in PCDD/F levels.	Grecat SA, Spain	Moderate	Moderate	High	Moderate	Yes
29	Chao, C. L. and Hwang, K. C. 2005 Journal of Postgraduate Medicine Arsenic burden survey among refuse incinerator workers	122	Age-matched	Sex-matched	Residents of the vicinity.	Living there for 6 months.	Unspecified	Yes	Blood and Urine	Arsenic	Atomic Absorption	Various Statistical Tests Perfomed	122	Yes, study found levels of arsenic to be higher in incinerator workers	Incinerator workers run the risk of being exposed to arsenic pollution, especially those who have incomplete protection in the workplace even though they only have indirect or no contact with combustion-generated pollutant	Not specified.	Moderate	Moderate	Moderate	Moderate	Yes
50	Domingo, J. L., Schuhmacher, M., Agramunt, M. C., Muller, L., and Neugebauer, F. 2001 Int.Arch.Occup.Environ.Health Levels of metals and organic substances in blood and urine of workers at a new hazardous waste incinerator	N/A	N/A	N/A	N/A	N/A	1 year	Yes	Blood, Urine	PCDD/F, PCB, HCB, Be, Mn, Hg, Pb, As, Cd, Cr, Ni, V, DCP, TCP, PCP, 1-HP	Organics: GC/MS; Metals: ICP/MS;	Kruskal-Wallis, Mann-Whitney	28	Baseline Study	Most concentrations observed were on the same order of magnitude as those observed in previous studies. More chlorinated PCDD/F congenrs found in higher concentrations - consistent with longers half-lives for these compounds.	UTE-BASF Espanola, SA-EMTE, Spain	Moderate	Moderate	High	Moderate	Yes
93	Kumagai, S., Koda, S., Miyakita, T., Yamaguchi, H., Katagi, K., and Yasuda, N. 2000 Occupational and Environmental Medicine Polychlorinated dibenzo-p-dioxin and dibenzofuran concentrations in the serum samples of workers at continuously burning municipal waste incinerators in Japan	30	38-59	Not specified.	Municipal governmental employees in same area as incinerator.	No prior occupational exposure.	Not specified.	Yes	Blood	PCDD/F	GC/MS	Mann-Whitney	20 for each area	No TEQ relationship. Statistically higher concentration of 1,2,3,4,6,7,8-HpCDF was higher in incineration workers suggesting workers inhaled dust containing PCDD/Fs during work.	Serum TEQ in all of the incinerator workers and controls were almost the same as other industrialized countries. No significant differences between TEQ levels of workers and controls. Statistically higher concentration of 1,2,3,4,6,7,8-HpCDF was higher in incineration workers suggesting workers inhaled dust containing PCDD/Fs during work.	Grant-in Aid for Scientific Research	Moderate	Moderate	High	Moderate	Yes

Source			Incinerator			Study Design	Study Group				
Ref ID	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
94	Kumagai, S., Koda, S., Miyakita, T., and Ueno, M. 2002 Occupational and Environmental Medicine Polychlorinated dibenzo-p-dioxin and dibenzofuran concentrations in serum samples of workers at intermittently burning municipal waste incinerators in Japan	OBJECTIVES: To find whether or not incinerator workers employed at intermittently burning municipal incineration plants are exposed to high concentrations of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). METHODS: 20 Workers employed at three municipal waste incineration plants (incinerator workers) and 20 controls were studied. The previous job, dietary, smoking, and body weight and height were obtained from a questionnaire survey. Concentrations of PCDDs and PCDFs were measured in serum samples of the workers and the deposited dust of the plants. The influence of occupational exposure on concentrations of PCDDs and PCDFs in serum samples was examined by multiple regression analysis. RESULTS: Dust analysis showed that dominant constituents were octachlorodibenzo-p-dioxin (OCDD) and 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin (HpCDD) among the PCDDs, and 1,2,3,4,6,7,8-heptachlorodibenzofuran (HpCDF) and octachlorodibenzofuran (OCDF) among the PCDFs. The toxicity equivalents (TEQs) of summed PCDDs and PCDFs in the deposited dust were 0.91, 33, and 11 ng TEQ/g, respectively, for plants I, II, and III. The means of TEQ in serum samples of summed PCDDs and PCDFs in the incinerator workers and controls were 22.8 and 16.4 pg TEQ/g lipid for area I, 29.4 and 19.3 pg TEQ/g lipid for area II, and 22.8 and 24.9 pg TEQ/g lipid for area III, which were almost the same as for the general population of Japan. No significant differences in the TEQ of PCDDs and TEQ of PCDDs and PCDDs were found between the incinerator workers and the controls. However, the TEQ of PCDFs was significantly higher among the incinerator workers in areas I and II, and the 1,2,3,4,6,7,8-HpCDF concentration was also significantly higher for all three areas. When the occupational exposure index for each constituent of PCDDs and PCDFs was defined as the product of the duration of employment at the incineration plant and the concentration of the constituent in the deposited dust, multiple regression analysis showed that the concentrations of HxCDF, HpCDF, and TEQ of PCDFs in serum samples increased with the occupational exposure index. The multiple regression analysis also suggested that significant factors affecting the concentrations in serum samples were area for HxCDD, age for TCDD, PeCDD, PeCDF, TEQ of PCDDs, TEQ of PCDFs, and TEQ of summed PCDDs and PCDFs, and BMI for HxCDD, HpCDD, and OCDD. CONCLUSION: This study showed that incinerator workers employed at intermittently burning incineration plants were not necessarily exposed to high concentrations of	Nagasaki, Chiba and Nagano prefectures, Japan	3 municipal waste incinerators	Not specified.	Cross-sectional, prospective	20	24-59	Not specified.	Workers - Various positions	Mean employment term 10-16 years
97	Lee, S. J., Ikonomou, M. G., Park, H., Baek, S. Y., and Chang, Y. S. 2007 Chemosphere Polybrominated diphenyl ethers in blood from Korean incinerator workers and general population	This study was conducted to examine PBDE exposure in Koreans, with a special focus on incinerator workers due to their potential for occupational exposure to PBDEs. A total of 92 blood samples from 30 incinerator workers, 51 nearby residents and 11 controls were analyzed. The mean total PBDE concentration calculated from the 13 most concentrated congeners for all samples was 16.84+/-7.48 ng/g lipid, which was somewhat higher concentration than in other countries except North America and Canada. The PBDE levels and congener profiles detected in incinerator workers were not distinctly different from those found in the general population. In all groups tested, BDE-47 was dominant (mean contribution=32.5%) followed by BDE-153 (23.6%) and relatively high portions of BDE-183 (16.5%) were found. No strong trend was observed between PBDE levels and a number of key biological factors examined in this study, however, weak correlations were observed in PBDE levels measured against dietary habits, particularly in fish consumption frequency and gender. Overall, our data suggest that the occupational exposure of incinerator workers to PBDEs can be considered minor, while other lifestyle factors can have a greater contribution to PBDE exposure	4 incinerators in Seoul, Korea	3 Municipal, 1 Industrial	Not specified.	Cross-Sectional, Prospective	30	28-68	Male	Workers - Various positions	Employed 0-15 years
113	Mari, M., Schuhmacher, M., and Domingo, J. L. 8-20-2008 Int.Arch.Occup.Environ.Health Levels of metals and organic substances in workers at a hazardous waste incinerator: a follow-up study	PURPOSE: To determine the blood and urine concentrations of a number of metals and organic substances in workers at a hazardous waste incinerator (HWI) in Catalonia, Spain, 8 years after regular operations in the facility. To compare these concentrations with the baseline (1999) levels and with those obtained in previous (2000 and 2005) surveys. METHODS: The employees were divided into three groups according to their specific workplaces. Plasma analyses of hexachlorobenzene (HCB), polychlorinated biphenyls (PCBs 28, 52, 101, 138, 153 and 180) and polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), as well as urinary analyses of 2,4- and 2,5-dichlorophenol (DCP), 2,4,5- and 2,4,6-trichlorophenol (TCP), pentachlorophenol (PCP) and 1-hydroxypyrene (1-HP) were carried out. Blood concentrations of manganese and mercury, and urinary levels of nickel were also determined. RESULTS: For organic compounds in plasma, the comparison of the current levels with those of previous surveys did not show any significant increase for any of the compounds analyzed. In contrast, plasma levels of PCBs 28, 52 and 101 were significantly lower than the respective baseline concentrations, while especially notable was the significant reduction in the levels of PCDD/Fs in plasma of plant workers, which decreased from 26.7 pg I-TEQ/g lipid in the baseline survey to the current 2.5 pg I-TEQ/g lipid. CONCLUSION: According to the results of the present study, there are no evident signs of occupational exposure to a number of metals and organic substances in the workers of the HWI	Constanti, Spain	Hazardous Waste Incinerator	2000	Longitudinal, Prospective	29	Unspecified.	19 men, 10 women	Workers	8 years of employment at the incinerator, either as an operations, laboratory, or management worker.
114	Mari, M., Borrajo, M. A., Schuhmacher, M., and Domingo, J. L. 2007 Chemosphere Monitoring PCDD/Fs and other organic substances in workers of a hazardous waste incinerator: a case study	The aim of this study was to measure, 6 years after regular operations, the concentrations of a number of organic substances in blood and urine of 19 workers employed at a hazardous waste incinerator (HWI) in Spain, and to establish the temporal variation with respect to baseline data and previously performed surveys. This facility was the first, and so far the only HWI in that country. The levels of hexachlorobenzene (HCB), polychlorinated biphenyls (PCB 28, 52, 101, 138, 153 and 180) and polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) were analyzed in six composite plasma samples, while concentrations of di-, tri, and pentachlorophenols, as well those of 1-hydroxypyrene were measured in the urine of these workers. The current mean PCDD/F concentration, 10.4 ng I-TEQ/kg lipid, was significantly lower than that found in the baseline survey, 26.7 ng I-TEQ/kg lipid and similar to that found in the previous (2004) study (7.7 ng I-TEQ/kg lipid). PCDD/F levels in plasma were similar or even lower than those recently reported for various non-exposed populations. For the remaining analyzed substances in plasma and urine, there was not any significant increase in comparison with the levels found in the baseline survey. On the other hand, no marked differences between the concentrations of organic substances in plasma or urine were found according to the respective workplace (plant, laboratory and administration). The results of the present survey indicate that after 6 years of regular operation, the workers at the HWI are not occupationally exposed to PCDD/Fs and other organic substances in their workplaces	Constanti, Spain	Hazardous Waste Incinerator	1999	Longitudinal, Prospective	19	27-41	15 men, 4 women	Workers	6 years of employment at the incinerator, either as an operations, laboratory, or management worker.

Source		Control Group					Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Citation	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Study Duration	Was Lifestyle Questionnaire Provided to Participants?	Medium Sampled	Chemicals/ Outcome Assessed	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
94	Kumagai, S., Koda, S., Miyakita, T., and Ueno, M. 2002 Occupational and Environmental Medicine Polychlorinated dibenzo-p-dioxin and dibenzofuran concentrations in serum samples of workers at intermittently burning municipal waste incinerators in Japan	20	27-58	Not specified.	Municipal governmental employees in same area as incinerator.	No prior occupational exposure.	Not specified.	Yes	Blood	PCDD/F	GC/MS	Mann-Whitney	14 for each incinerator	No TEQ relationship. Statistically higher concentration of 1,2,3,4,6,7,8-HpCDF was higher in incineration workers suggesting workers inhaled dust containing PCDD/Fs during work.	Serum TEQ in all of the incinerator workers and controls were almost the same as other industrialized countries. No significant differences between TEQ levels of workers and controls. Statistically higher concentration of 1,2,3,4,6,7,8-HpCDF was higher in incineration workers suggesting workers inhaled dust containing PCDD/Fs during work.	Not specified.	Moderate	Moderate	High	Moderate	Yes
97	Lee, S. J., Ikonomou, M. G., Park, H., Baek, S. Y., and Chang, Y. S. 2007 Chemosphere Polybrominated diphenyl ethers in blood from Korean incinerator workers and general population	62	22-74	21 male, 41 female	51 residents living within 1 km of facility and 11 residents living 6-20 km from facility.	None identified.	Not specified.	Yes	Blood	PBDE	GC/MS	ANOVA	92	None identified.	Occupational exposure to PBDEs for incinerator workers is less significant than other exposure pathways. Accumulation of PBDEs in human body depends on many diverse and complex factors, including indoor-living environment, electronics and computer usage, dietary intake. No correlations between PBDE levels and factors such as age, weight, height, body fat, dietary habits. Men showed distinctly higher levels than women, likely due to societal factors, placental excretion and lactation.	Korea Research Foundation	Moderate	Moderate	Moderate	Moderate	Yes
113	Mari, M., Schuhmacher, M., and Domingo, J. L. 8-20-2008 Int.Arch.Occup.Environ.Health Levels of metals and organic substances in workers at a hazardous waste incinerator: a follow-up study	28	23-58	22 men, 6 women	Workers	No Previous Occupational Exposure - Incinerator Not Operational Yet	9 years	Yes	Blood, Urine	PCDD/F, PCB, HCB, Mn, Hg, Ni, DCP, TCP, PCP, 1-HP	GC/MS	Kruskal-Wallis, Mann-Whitney	29	None identified.	After 8 years of regular operation, no evident signs of internal exposure to a number of inorganic and organic substances were found. Most concentrations were similar or lower than baseline levels.	Grecat SA, Spain	Moderate	Moderate	High	Moderate	Yes
114	Mari, M., Borrajo, M. A., Schuhmacher, M., and Domingo, J. L. 2007 Chemosphere Monitoring PCDD/Fs and other organic substances in workers of a hazardous waste incinerator: a case study	28	23-58	22 men, 6 women	Workers	No Previous Occupational Exposure - Incinerator Not Operational Yet	8 years	Yes	Blood, Urine	PCDD/F, PCB, HCB, DCP, TCP, PCP, 1-HP	GC/MS	Kruskal-Wallis, Mann-Whitney	19	None identified.	After 6 years of regular operation, no evident signs of internal exposure to a number of inorganic and organic substances were found. Most concentrations were similar or lower than baseline levels. No important differences between previous post-baseline monitoring studies.	Grecat SA, Spain	Moderate	Moderate	High	Moderate	Yes

Source			Incinerator			Study Design	Study Group				
Ref ID	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
155	Schecter, A., Papke, O., Ball, M., Lis, A., and Brandt-Rauf, P. 1995 Occupational and Environmental Medicine Dioxin concentrations in the blood of workers at municipal waste incinerators	OBJECTIVES--Increased concentrations of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzo-furans (PCDFs) in pooled blood samples from workers at municipal waste incinerators have been reported. This study was undertaken to confirm these results in individual blood samples from potentially exposed and unexposed workers at municipal waste incinerators compared with matched unexposed controls and compared with concentrations in the slag and fly ash from the municipal waste incinerators. METHODS--Concentrations of PCDDs and PCDFs were determined in the blood of 10 workers from an old municipal waste incinerator without adequate pollution controls, 11 workers from a newer incinerator with modern pollution controls, and 25 controls from the general population group matched for age (+/- 10 years), sex, and race, and in the slag and fly ash from the older incinerator. RESULTS--Significant increases of certain PCDDs and PCDFs were found in the blood of the workers from the older incinerator compared with the controls as follows: octaCDD (1051 (438) v 637 (344), P < 0.001), hexaCDF (52.3 (28.7) v 30.2 (18.2), P < 0.01), heptaCDF (43.9 (30.4) v 22.7 (12.4), P < 0.001), total PCDDs (1262 (484) v 825 (454), P < 0.001), total PCDFs (133.0 (68.1) v 93.7 (36.7), P < 0.05), and total PCDD/Fs (1395 (537) v 918 (437), P < 0.001). The workers from the older incinerator with the greatest exposure were found to have the most significant increases of the blood PCDDs and PCDFs, and the pattern of increased PCDD and PCDF congeners in the blood corresponded to the pattern in the incinerator slag and ash. No significant differences were found between the blood concentrations of the workers at the newer incinerator and the controls. CONCLUSION--Occupational exposure to slag and fly ash from municipal waste incinerators may increase the blood concentrations of PCDDs and PCDFs. Modern pollution control technology in new incinerators may be able to minimise potential exposure to slag and fly ash and thus the absorption of PCDDs and PCDFs from this source	2 incinerators in Germany	Municipal Solid Waste	1 old incinerator, 1 new incinerator	Cross-Sectional, Prospective	21	33-58	Men	Workers - Various positions	Employed in plant for 2-24 years.
162	Schuhmacher, M., Domingo, J. L., Agramunt, M. C., Bocio, A., and Muller, L. 2002 Int.Arch.Occup.Environ.Health Biological monitoring of metals and organic substances in hazardous-waste incineration workers	OBJECTIVES: To determine blood and urine concentrations of a number of metals and organic substances in workers at a hazardous-waste incinerator (HWI) 1 year after regular operations in the facility, and to compare these concentrations with the baseline levels. METHODS: The employees were divided into three groups according to their workplaces. Plasma analyses of hexachlorobenzene (HCB), polychlorinated biphenyls (PCBs 28, 52, 101, 138, 153 and 180) and polychlorinated dibenzo- p-dioxins and dibenzofurans (PCDD/Fs), and urinary analyses of 2,4- and 2,5-dichlorophenol (DCP), 2,4,5- and 2,4,6-trichlorophenol (TCP), pentachlorophenol (PCP) and 1-hydroxypyrene (1-HP) were carried out. The blood concentrations of beryllium, manganese, mercury and lead, and the urine levels of cadmium, chromium, nickel and vanadium were also determined. RESULTS: The current plasma HCB, PCB and PCDD/F levels, and the urine levels of chlorophenols (CLPs) and 1-HP did not show significant differences between workplace groups or the baseline concentrations. Moreover, no significant differences between metal levels could be observed. DISCUSSION AND CONCLUSION: The lack of differences between the current levels of metals and organic substances and the respective baseline concentrations, together with the absence of differences depending on the workplace indicate that the potential exposure of HWI workers to the analyzed compounds was insignificant. According to these results, 1 year of potential exposure to the above metals and organic substances would not mean any specific health problem for the workers at the HWI	Constanti, Spain	Hazardous Waste Incinerator	1999	Longitudinal, Prospective	23	24-35	18 men, 5 women	Workers	1 year of employment at the incinerator, either as an operations, laboratory, or management worker.
179	Shih, T. S., Chen, H. L., Wu, Y. L., Lin, Y. C., and Lee, C. C. 2006 Chemosphere Exposure assessment of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) in temporary municipal-waste-incinerator maintenance workers before and after annual maintenance	Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) have been found in ambient air around municipal waste incinerators (MWIs), and elevated serum levels in incinerator workers have also been observed in some studies. However, few studies have focused on temporary employees who work intermittently through the annual maintenance and clean-up around different incinerators. The present study aimed to assess the change in serum PCDD/F levels of temporary employees between the beginning of periodic incinerator maintenance and one month the work was completed. Thirty-five volunteer workers, most of them transient and temporary maintenance staff, were recruited from a contractor that provided annual maintenance for four incinerators in this study. Information about each participant was obtained by questionnaire at the beginning of annual maintenance. The questionnaire asked for work history, health status, and diet information. As measured by the PCDD/F levels in blood, a significant increase was observed in workers after a month of maintenance work. The increase was greater in workers who had never done this type of maintenance than in those with previous experience, especially for 2,3,4,6,7,8-HxCDF levels. The data also showed that the laborers and employers need to pay more attention to occupational health issues even for short-term incinerator maintenance workers	4 incinerators in Taiwan	Municipal Solid Waste	Not specified.	Longitudinal, Prospective	35	Mean Age - 41	34 men; 1 women	Maintenance Workers	1 month of maintenance work in the facility

Source		Control Group					Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Citation	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Study Duration	Was Lifestyle Questionnaire Provided to Participants?	Medium Sampled	Chemicals/ Outcome Assessed	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
155	Schecter, A., Papke, O., Ball, M., Lis, A., and Brandt-Rauf, P. 1995 Occupational and Environmental Medicine Dioxin concentrations in the blood of workers at municipal waste incinerators	25	33-52	Male	German General Population	No known occupational exposure.	Not specified.	Yes	Blood	PCDD/F	GC/MS	Student's t-test	46	Some significantly higher levels in old incinerator workers with respect to control.	Authors could not definitively conclude that difference in concentrations between two groups of incinerator workers due to differences in pollution control technology. No significant differences between new workers and control, while some differences between old workers and control.	Not specified.	Moderate	Moderate	High	Moderate	Yes
162	Schuhmacher, M., Domingo, J. L., Agramunt, M. C., Bocio, A., and Muller, L. 2002 Int.Arch.Occup.Environ.Health Biological monitoring of metals and organic substances in hazardous-waste incineration workers	28	23-58	22 men, 6 women	Workers	No Previous Occupational Exposure - Incinerator Not Operational Yet	2 years	Yes	Blood, Urine	PCDD/F, PCB, HCB, Be, Mn, Hg, Pb, Cd, Cr, Ni, V, DCP, TCP, PCP, 1-HP	Organics: GC/MS; Metals: ICP/MS;	Kruskal-Wallis, Mann-Whitney	23	None identified.	1 year of potential exposure to organic and inorganic substances did not show any specific health problems for workers at the HWI. No signficant differences observed between workers in any of the three analyzed worker groups, or with respect to baseline levels.	Grecat SA, Spain	Moderate	Moderate	High	Moderate	Yes
179	Shih, T. S., Chen, H. L., Wu, Y. L., Lin, Y. C., and Lee, C. C. 2006 Chemosphere Exposure assessment of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) in temporary municipal-waste-incinerator maintenance workers before and after annual maintenance	35	Mean Age - 41	34 men; 1 women	Maintenance Workers	Prior to Maintenance work in the facility	1 month	Yes	Blood	PCDD/F	GC/MS	Wilcoxon-Matched Pairs test. Kruskal Wallis.	35	Significant difference observed in levels of employees with no previous MWI experience. Marginally significant difference in those with previous experience.	High correlation of levels before and after maintenance. Significant increase observed in temporary workers after 1 month - increase larger in workers with less on-the-job experience. Findings suggest a change in metabolic mechanism for some PCDD/F congeners in people with higher exposure lengths.	Council of Labour Affairs, Taiwan	Moderate	Moderate	High	Moderate	Yes

APPENDIX C-2B

Human Biomonitoring of Facility Employees - Excluded

Source			Incinerator			Study Design	Study Group				
Ref ID	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
8	Angerer, J., Heinzow, B., Reimann, D. O., Knorz, W., and Lehnert, G. 1992 Int.Arch.Occup.Environ.Health Internal exposure to organic substances in a municipal waste incinerator	Fifty-three persons occupied in a municipal waste incinerator were examined with respect to their internal exposure to organic substances which may be produced during pyrolysis of organic matter. For this purpose the levels of benzene in blood, polychlorinated biphenyls (PCBs) and hexachlorobenzene (HCB) in plasma, and mono-(MCPs), di- (DCPs), tri- (TCPs), tetra- (TCEPs) and pentachlorophenol (PCP) and hydroxypyrene in urine were determined. For control purposes, 431 men and women were examined. Significantly higher values for the workers were found for the excretion of hydroxypyrene [median (m): 0.24 vs 0.11 microgram/l; non-smokers], 2,4/2,5-DCP (m: 10.5 vs 3.9 micrograms/l) and 2,4,5-TCP (m: 1.2 vs 0.8 micrograms/l) and for the HCB level in plasma (m: 4.4 vs 2.8 micrograms/l). For the concentrations of 4-MCP and 2,3,4,6/2,3,5,6-TECP, the controls had significantly higher concentrations in urine than did the workers in the incineration plant (m: 4-MCP 1.7 vs 1.2; 2,3,4,6/2,3,5,6-TECP: 1.2 vs 0.3 micrograms/l). No significant differences between workers and controls were detected with respect to benzene in blood (m: 0.20 vs 0.28 microgram/l; non-smokers), 2,4,6-TCP and PCPs in urine (m: 0.85 vs 0.60 and 2.2 vs 2.2 micrograms/l) or the levels of PCB congeners in plasma (m: sigma 138, 153, 180: 5.6 vs 4.1 micrograms/l). The elevated levels of hydroxypyrene, 2,4/2,5-DCP, 2,4,5-TCP and HCB in biological material may be related to the incineration of the waste. These elevations, however, are very small and are of interest more from the environmental than from the occupational point of view	Germany	Municipal Solid Waste	Not specified.	Cross-Sectional, Prospective	53	22-52	50 men; 3 women	Workers	Employed 0.5-14 years
73	Hoffman, B. H., Tuomanen, B., Price, III R., and Beaulieu, H. J. 1997 Applied Occupational and Environmental Hygiene Biological monitoring of employees with potential exposures to inorganic lead and cadmium at municipal solid waste resource recovery, or trash-to- energy, facilities	Resource recovery (trash-to-energy) facilities reduce the volume of municipal solid waste through incineration, while generating steam for the production of electrical power. The noncombustible, dustlike ash residue produced by these plants is composed of inorganic constituents and metal contaminants which are concentrated from the original trash, including inorganic lead and cadmium. Handling and working around the ash has the potential to cause worker exposures to these metals. This ash is ultimately disposed of in appropriately designed and permitted landfills. Although overall lead and cadmium exposures to workers in the industry are generally quite low. A small number of dusty jobs such as ash handlers have resulted in exposures that exceed the Occupational Safety and Health Administration permissible exposure limit for lead. Personal protective equipment (PPE), and in particular personal respiratory protection (air-purifying respirators with high efficiency particulate air filtration), and appropriate hygienic work practices (protective clothing, showers and hand washing, and lunchroom facilities) are used by workers to control potential exposures to airborne lead and cadmium. Biological monitoring of the work force confirms that file PPE and hygienic work practices programs are effective in controlling worker exposures to lead and cadmium	Unspecified.	10 Municipal Waste Incinerators	Range from 1982-1996	Cross-Sectional, Prospective	209-1404 depending on outcome measured	Unspecified.	Unspecified.	Workers - Various positions	Employed at the facility.
76	Hu, S. W., ChangChien, G. P., and Chan, C. C. 2004 Chemosphere PCDD/Fs levels in indoor environments and blood of workers of three municipal waste incinerators in Taiwan	This study monitored ambient air concentrations of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/Fs) in three municipal waste incineration plants. Blood PCDD/Fs levels of 133 workers randomly selected from these plants were also measured. The associations between workers' blood PCDD/Fs concentrations and occupational exposures to PCDD/Fs were assessed. Means of air PCDD/Fs levels ranged from 0.08 to 3.01 pg/m3 in international toxic equivalents (I-TEQ). The geometric means of blood PCDD/Fs concentrations were 14.6, 15.8, 19.1 pg/g lipid in World Health Organization (WHO) TEQ, respectively, for workers from three plants. Air levels of total I-TEQ and all congeners, except 2,3,7,8-tetrachlorinated dibenzo-p-dioxin (TeCDD) and 1,2,3,4,7,8,9-heptachlorinated dibenzofuran (HpCDF), were significantly higher in plant B. However, blood concentrations of 2,3,7,8-TeCDD, 1,2,3,7,8-PeCDD, 2,3,7,8-TeCDF, 1,2,3,7,8-PeCDF and 1,2,3,4,7,8,9-HpCDF were significantly elevated in plant C workers. Although job contents, duration of employment and time spent in certain location were significantly different among incineration plants, they were not significantly associated with blood concentrations of any congener. Furthermore, results of the multiple regression analysis that assessed important occupational factors simultaneously and adjusted for potential confounders, showed significant associations between four congeners and incineration plant or job contents. However, the results were limited by small R-squares of the regression models. In conclusion, blood concentrations of several PCDD/Fs congeners were significantly different among three incineration plants. The differences were not explained by the discrepancy in job contents, duration of employment, and time activity in these plants	Northern Taiwan	3 Municipal waste incinerators	Range from 1991-1998	Cross-Sectional, Prospective	133	Mean Age: 38-42	Male	Workers - Various positions	Employment minimum 6 months. Mean range 2.6-7.2 years.
79	Ichiba, M., Ogawa, Y., Mohri, I., Kondoh, T., Horita, M., Matsumoto, A., Yoshida, R., Matsumoto, Y., Saito, H., Ohba, K., Yamashita, Z., and Tomokuni, K. 2007 J.Occup.Health Analysis of urinary metabolites of polycyclic aromatic hydrocarbons in incineration workers	Incineration workers are exposed to various pyrolysis products of organic materials, heavy metals and polycyclic aromatic hydrocarbons (PAHs). In this study, the exposure of incineration workers to PAHs was evaluated by measuring urinary metabolites of pyrene and naphthalene. The concentrations of urinary 1-hydroxypyrene (1OHP), a metabolite of pyrene, and 2-naphthol (2NP), a metabolite of naphthalene, were measured among 100 workers in 4 different types of incinerators, both before and after their work shifts. These incinerators were two old types, one modern type and one outdoors. The medians of urinary 1OHP of before and after the work shifts obtained from all workers were 0.067 and 0.044 mug/gCr, respectively; and the medians of urinary 2NP were 7.5 and 10.0 mug/gCr, respectively. A significant increase of 2NP after the work shift was found at one old incinerator. A significant decrease of metabolites was found at the other old incinerator. Significant correlations were found between urinary metabolites and cigarettes smoked per day. The effect of smoking on urinary metabolite levels was also important. Significant correlations were found between urinary 1OHP and 2NP levels in all workers. In multiple regression analysis smoking habit and incinerator type were found as significant factors. The improvement of the work environment, through decreasing exposure to both tobacco smoke and hazardous work shift-related substances, should be an occupational health aim	Japan	3 municipal waste incinerators; 1 industrial waste incinerator	1976; 1973; 2002; 1991	Longitudinal, Prospective	100	22-64	96 male; 4 female	Workers - Various positions	Employed at the facility.

Source		Control Group					Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Citation	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Study Duration	Was Lifestyle Questionnaire Provided to Participants?	Medium Sampled	Chemicals/ Outcome Assessed	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
8	Angerer, J., Heinzow, B., Reimann, D. O., Knorz, W., and Lehnert, G. 1992 Int.Arch.Occup.Environ.Health Internal exposure to organic substances in a municipal waste incinerator	431 (not all tested for each parameter)	18-84	Both	Residents of Schleswig-Holstein and Franconia, Germany	No known occupational exposure.	Not specified.	Not specified.	Blood, Urine	Benzene, hydroypyrene, PCB, HCB, MCP, DCP, TCP, TECP, pentachlorophenol	GC or HPLC-F for hydroxypyrene	Wilcoxon, Mann-Whitney	Varies depending on parameter.	Concentrations of hydroxypyrene, 2,4/2,5 DCP, 2,4,5-TCP and HCB were statistically higher in study group vs. control. Other chemicals showed no significant differences.	Differences may have been caused by incineration process, however, from an occupational health point of view, the increases are of minor importance.	Not specified.	Moderate	Moderate	Low	Moderate	No
73	Hoffman, B. H., Tuomanen, B., Price, III R., and Beaulieu, H. J. 1997 Applied Occupational and Environmental Hygiene Biological monitoring of employees with potential exposures to inorganic lead and cadmium at municipal solid waste resource recovery, or trash-to- energy, facilities	No control group.	N/A	N/A	N/A	N/A	Unspecified	Unspecified	Blood, Urine	Pb, Cd	AAS, ICP/MS	None	N/A	None identified.	Vast majority of employees are likely to have very low exposures to lead and cadmium bearing ash dust. Biological monitoring indicated that data were consistently below regulatory and recommended limits for lead and cadmium. Worker protection programs including use of PPE are effective in controlling exposures to lead and cadmium.	Not specified.	Low	Very Low	Low	Low	No
76	Hu, S. W., ChangChien, G. P., and Chan, C. C. 2004 Chemosphere PCDD/Fs levels in indoor environments and blood of workers of three municipal waste incinerators in Taiwan	No control group.	N/A	N/A	N/A	N/A	Unspecified	Yes	Blood	PCDD/F	Previously published method based on US EPA Method 1613 Revision B	Kruskal-Wallis	133	No significant differences between TEQ levels at 3 plants. No control group for comparison.	No significant differences between TEQ levels at 3 plants. Some differences in individual congeners. Discrepancies could not be explained by confounding factors.	Environmental Protection Bureau of Taipei City, Taiwan	Low	Moderate	Moderate	Moderate	No
79	Ichiba, M., Ogawa, Y., Mohri, I., Kondoh, T., Horita, M., Matsumoto, A., Yoshida, R., Matsumoto, Y., Saito, H., Ohba, K., Yamashita, Z., and Tomokuni, K. 2007 J.Occup.Health Analysis of urinary metabolites of polycyclic aromatic hydrocarbons in incineration workers	No control group.	N/A	N/A	N/A	N/A	2 years	Not specified.	Urine	1OHP, 2NP (PAH metabolites)	HPLC	Nonparametric model.	100	Signficant differences between before and after work shifts were found, particularly at older incinerators. Smokers always showed higher levels of metabolites	Effect of smoking was an important factor in PAH exposure levels. Higher internal expsoures may exist at older incinerators.	Not specified.	Low	Moderate	Low	Moderate	No

Source			Incinerator			Study Design	Study Group				
Ref ID	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
86	Kim, Y., Yang, S. H., Kim, M., and Shin, D. C. 2001 Chemosphere PCDD and PCDF exposures in workers and controls living near an industrial waste incinerator	This study measured the levels of 17 congeners of PCDDs/PCDFs in serum to compare the levels between potentially exposed workers at an industrial waste incinerator and any residents with no known exposures. The 1,2,3,6,7,8- and 1,2,3,7,8,9-HxCDD were detected in serum of workers but in controls. Likewise, 1,2,3,7,8-PeCDF, 1,2,3,6,7,8- and 1,2,3,7,8,9-HxCDF were detected only in serum of workers. The international toxic equivalent (TEQ) levels of PCDDs/PCDFs in sera of workers are much higher than in controls. Among PCDDs, the proportion of total concentration and TEQ level is dominated predominantly by 1,2,3,6,7,8- and 1,2,3,7,8,9-HxCDD. We need extensive studies to estimate human exposure and are continuing this investigation	Korea	Industrial Waste Incinerator	Not specified.	Cross-Sectional, Prospective	15	24-47	1 male; 14 females	Workers	Employed at the facility.
89	Kitamura, K., Kikuchi, Y., Watanabe, S., Waechter, G., Sakurai, H., and Takada, T. 2000 Journal of Epidemiology Health effects of chronic exposure to polychlorinated dibenzo-P-dioxins (PCDD), dibenzofurans (PCDF) and coplanar PCB (Co-PCB) of municipal waste incinerator workers	A national survey of polychlorinated dibenzo-p-dioxins (PCDD) and dibenzofurans (PCDF) in emission gases from the municipal waste incinerators in 1997 revealed that the Nose Bika Center was heavily contaminated by PCDF. Ninety-four workers underwent a physical examination, and blood biochemistry, lymphocyte marker, and NK activity studies were carried out, along with blood dioxin measurements. Information on working history, life-style, and dietary habits was obtained by questionnaire and interview. The blood dioxin levels were as follows. The median TEQ of dioxins was 39.7 pg I-TEQ/g lipid, and the range was 13.3 to 805.8. The median 2,3,7,8-TCDD concentration was 3.9 pg TEQ/g lipid, and the range was <1 pg TEQ/g lipid (one case) to 13.4 pg TEQ/g lipid. The median TEQ of coplanar PCB was 10.8 pg I-TEQ/g lipid, and the range was 3.1 to 54.2 pg TEQ/g lipid. The congener-specific distribution was quite similar to that in soil around incinerator and waste in the factory. The relationship between dioxin concentrations and work history in the factory showed that the fluidized incinerator and fly ash treatment areas were high-risk work areas. Correlation analyses between body burden, PCDD/PCDF TEQ, Co-PCB TEQ and various laboratory data showed significant positive correlations between dioxin levels and GGT, total protein, uric acid and calcium, and a negative correlation with Fe. However, these correlations disappeared as a result of multivariate analysis adjusted for age, smoking status, and alcohol drinking. Increased NK activity and lower response to PHA stimulation remained significant even after adjusting for age. History of hyperlipidemia and allergy had significantly increased odds ratios. A study on the risk to other workers in the same type of incinerators is under way. Health effects of chronic exposure mainly to PCDF will be clarified by follow-up	Bika Center, Osaka Prefecture, Japan	Municipal Solid Waste	1988-1997	Cross-Sectional, Prospective	92	16-78	88 males/ 4 females	Workers	Employed at some point since opening of facility ~10 years
109	Ma, X. F., Babish, J. G., Scarlett, J. M., Gutenmann, W. H., and Lisk, D. J. 1992 J.Toxicol.Environ.Health Mutagens in urine sampled repetitively from municipal refuse incinerator workers and water treatment workers	In order to reduce their energy costs, many cement plants use fuel product substitutes (old tyres and used oil). The combustion of these products generates a metal increase (e.g. Cu, Cd, Pb and Zn) in the atmospheric emissions. After their release, these elements are deposited into the environment and could eventually accumulate up to concentrations of concern. At the Saint-Laurent cement factory (Joliette, QC, Canada), maximum deposition of these elements occurs in the direction of prevailing winds (North-East). We evaluated the potential impact of these depositions upon the immune system of three earthworm species (Lumbricus terrestris, Eisenia andrei and Aporrectodea tuberculata) exposed in a natural environment. The exposure sites were 0.5, 1.0, and 2.0 km downwind from the cement factory, along with an upwind reference site. The immune parameters studied were the cell viability and phagocytic potential of the immune cells (coelomocytes). For both L. terrestris and E. andrei, after 7 d exposure, none of the measured parameters showed significant differences among the sites. On the other hand, for the indigenous worm A. tuberculata, in the most exposed zone (at 0.5 km), we observed an increase in cell viability and phagocytic potential. This increase could possibly be attributed to physicochemical effects such as the alkaline pH of the soil, or alternatively, it could result from beneficial effects induced by an increased calcium supply	Assumed USA, Not specified.	4 Municipal Solid Waste	Range from 1984-1988	Longitudinal, Prospective	37 in first study, 33 in second, 24 in third	26-56	Male	Workers - Various positions	Employment range 1-10 years
110	Maitre, A., Collot-Fertey, D., Anzivino, L., Marques, M., Hours, M., and Stoklov, M. 2003 Occupational and Environmental Medicine Municipal waste incinerators: air and biological monitoring of workers for exposure to particles, metals, and organic compounds	AIMS: To evaluate occupational exposure to toxic pollutants at municipal waste incinerators (MWIs). METHODS: Twenty nine male subjects working near the furnaces in two MWIs, and 17 subjects not occupationally exposed to combustion generated pollutants were studied. Individual air samples were taken throughout the shift; urine samples were collected before and after. Stationary air samples were taken near potential sources of emission. RESULTS: Occupational exposure did not result in the infringement of any occupational threshold limit value. Atmospheric exposure levels to particles and metals were 10-100 times higher in MWIs than at the control site. The main sources were cleaning operations for particles, and residue transfer and disposal operations for metals. MWI workers were not exposed to higher levels of polycyclic aromatic hydrocarbons than workers who are routinely in contact with vehicle exhaust. The air concentrations of volatile organic compounds and aldehydes were low and did not appear to pose any significant threat to human health. Only the measurement of chlorinated hydrocarbon levels would seem to be a reliable marker for the combustion of plastics. Urine metal levels were significantly higher at plant 1 than at plant 2 because of high levels of pollutants emanating from one old furnace. CONCLUSION: While biological monitoring is an easy way of acquiring data on long term personal exposure, air monitoring remains the only method that makes it possible to identify the primary sources of pollutant emission which need to be controlled if occupational exposure and environmental pollution are to be reduced	France	2 Municipal waste Incinerators	1971 (renovated in 1993), and 1989	Longitudinal, Prospective	29 (15 from plant 1; 14 from plant 2)	Unspecified.	Male	Workers - Various positions	Employed at the facility.

Source		Control Group					Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Citation	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Study Duration	Was Lifestyle Questionnaire Provided to Participants?	Medium Sampled	Chemicals/ Outcome Assessed	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
86	Kim, Y., Yang, S. H., Kim, M., and Shin, D. C. 2001 Chemosphere PCDD and PCDF exposures in workers and controls living near an industrial waste incinerator	15	32-44	14 males; 1 female	Residents	None identified.	Not specified.	Not specified.	Blood	PCDD/F	GC/MS	None	30	Worker levels were higher than resident levels.	Workers show higher PCDD/F levels than residents with lower exposure.	Not specified.	Very Low	Low	Low	Low	No
89	Kitamura, K., Kikuchi, Y., Watanabe, S., Waechter, G., Sakurai, H., and Takada, T. 2000 Journal of Epidemiology Health effects of chronic exposure to polychlorinated dibenzo-P-dioxins (PCDD), dibenzofurans (PCDF) and coplanar PCB (Co-PCB) of municipal waste incinerator workers	No control group.	N/A	N/A	N/A	N/A	Not specified.	Yes	Blood	PCDD/F	GC/MS	Correlation Analysis - Unspecified.	92	Workers in higher exposure jobs showed higher levels than those with less expected exposure.	Workers in higher exposure setting jobs showed higher PCDD/F levels than those in lower exposure scenarios. Congener pattern in blood similar to that found in soil during previous study. Reasonable to conclude that source of exposure was incinerator environment.	Ministry of Labor, Japan	Low	Moderate	High	Moderate	No
109	Ma, X. F., Babish, J. G., Scarlett, J. M., Gutenmann, W. H., and Lisk, D. J. 1992 J.Toxicol.Environ.Health Mutagens in urine sampled repetitively from municipal refuse incinerator workers and water treatment workers	35 in first study, 34 in second, 32 in third	26-71	2 female, rest male	Workers at a municipal water treatment plant - low to no exposure to outcome of interest	Employment range 1-40 years	1 year	Yes	Urine	Mutagens	Ames Assay	chi-square test	56-72	Signfican difference between study and control group in first cohort, disappeared in 2nd and 3rd cohort.	In the first cohort, incinerator workers had a signficantly increased frequency of mutagens compared to water treatment workers. This significance disappeared in the 2nd and 3rd cohort. Due to reduction in incinerator workers, likely explained by high degree of variability in the measurements as employees not always performing the same task at the facility.	Not specified.	Moderate	Moderate	Very Low	Moderate	No
110	Maitre, A., Collot-Fertey, D., Anzivino, L., Marques, M., Hours, M., and Stoklov, M. 2003 Occupational and Environmental Medicine Municipal waste incinerators: air and biological monitoring of workers for exposure to particles, metals, and organic compounds	17	Unspecified.	Male	>10 km from incinerator	Supermarket employees - no occupational exposure.	1 year	Not specified.	Urine	As, Cd, Cr, Mn, Ni, 1-HP, TMA, OC, MHA	Metals - AAS; OC - GC/FID; 1-HP - HPLC-F; TMA, MHA - HPLC-UV	Mann-Whitney; Wilcoxon	46	Some metals correlated to incineration activities due to higher than control levels in workers. No correlation for organics.	Occupational exposure does not result in the infringement of any currently applicable occupational-medical TLV in France. Air monitoring is the only method for identification of primary sources of pollution and preventative human measures should be based on air monitoring results. No difference for any chemical or subject observed between start and end of shift. Significantly higher levels of Cd, Cr, and Ni observed between employees of older plant and controls. As levels at newer plant significantly higher than controls. No differences for organic compounds.	Ministry of Labor, Cancer Research Association, Environment Agency, France	Very Low	Very Low	Low	Moderate	No

Source			Incinerator			Study Design	Study Group				
Ref ID	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
111	Malkin, R., Brandt-Rauf, P., Graziano, J., and Parides, M. 1992 Environ.Res. Blood lead levels in incinerator workers	Questions have been raised concerning the safety of mass burn incineration and its role in solid waste management. In 1989, the New York City Office of Occupational Safety and Health examined air levels of metals in New York City incinerators and found that workers were exposed to air lead levels as high as 2500 micrograms/m3 while cleaning the electrostatic precipitators in the plant. In order to determine the biologic significance of these exposures to the workers, blood samples were taken from 56 incinerator workers and 25 controls and analyzed for lead and erythrocyte protoporphyrin levels. Incinerator workers were found to have a mean blood lead of 11.0 micrograms/dl as compared to the control group level of 7.4 micrograms/dl. Risk factors for increased blood lead levels were analyzed using multiple regression analyses. Wearing a personal protective device "always" or not and the interaction of smoking and cleaning the precipitator more than seven times in the past year were found to be significant predictors for blood lead. These results indicate that lead in municipal incinerator ash from electrostatic precipitators is bioavailable and that the effects of such exposure can be minimized by wearing personal protective devices, not smoking, and rotating the work force to minimize precipitator ash contact	New York	3 Municipal waste incinerators	Not specified.	Cross-Sectional, Prospective	56	22-61	Unspecified	Workers - Various positions	Employed at the facility.
130	Nakao, T., Aozasa, O., Ohta, S., and Miyata, H. 2005 Arch.Environ.Contam Toxicol. Survey of human exposure to PCDDs, PCDFs, and coplanar PCBs using hair as an indicator	Our environment is polluted with toxic compounds including polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and coplanar polychlorinated biphenyls (Co-PCBs). We investigated the suitability of hair analysis for testing human exposure to toxic compounds. Hair analysis revealed that municipal solid-waste (MSW) incineration workers were exposed to PCDDs, PCDFs, and Co-PCBs at high levels. The total 2,3,7,8-TCDD toxic equivalent concentration in MSW incineration workers was 2.5 times higher than in the general population, thus indicating that the indoor environment of the incineration facility was more polluted than the general environment. There were also characteristic patterns of occurrence of these dioxin-like compounds in the hair of smokers from the general population. We confirmed that hair analysis is useful for evaluating human exposure to PCDDs, PCDFs, and Co-PCBs in the atmosphere	Tokyo, Osaka and Hyogo, Japan	Municipal Solid Waste	Not specified.	Cross-Sectional, Prospective	68	Median - 44	Male	Workers	Yes
138	Papke, O., Ball, M., and Lis, A. 1993 Chemosphere Potential occupational exposure of municipal waste incinerator workers with PCDD/PCDF	The results of analyses of 10 whole blood samples from workers engaged in operating a Municipal Waste Incinerator (MWI) are reported. The values are compared to the so called 'background' values from 102 subjects in Germany. Concerning the MWI-workers it is striking that in certain cases the higher chlorinated dioxins and furans - especially the hexa-, hepta- and octa-CDD/CDF show elevated concentrations	South Germany	Municipal Solid Waste	Not specified.	Cross-Sectional, Prospective	10	33-52	Unspecified.	Workers	Employed 2-14 years.
142	Raemdonck, A., Koppen, G., Bilau, M., and Willems, J. L. 2006 Archives of Environmental and Occupational Health Exposure of maintenance workers to dioxin-like contaminants during the temporary shutdown of a municipal domestic solid waste incinerator: A case series	To evaluate workers' exposure to dioxin-like substances (such as polychlorinated dibenzo-p-dioxins, dibenzofurans, and polychlorinated biphenyls), the authors used a chemical-activated luciferase gene expression (CALUX) assay to determine serum dioxin-like activity in five workers before and after two different cleaning-up activities inside a municipal domestic solid-waste incinerator. The workers' mean serum concentration of dioxin-like substances before the first cleaning operation, shown as a weighted value of toxic equivalents (or TEQs) according to the CALUX test, was 17.2 pg CALUX TEQ/g fat (range = 12-22), which is comparable with concentrations found in similarly aged men in a Flemish environmental health pilot study. After cleaning work, the workers' mean serum concentration was 28.5 pg CALUX TEQ/g fat (range = 18-31). At the second plant stoppage, the workers' mean dioxin-like activity was 15.4 pg CALUX TEQ/g fat (range = 12-21) before and 16.4 pg CALUX TEQ/g fat (range = < 10-32, where 10 pg is the limit of determination) after the cleaning operation. These results indicate that workers may be exposed to dioxin-like substances during their performance of cleaning operations in a municipal domestic solid-waste incinerator.	Belgium	Municipal Solid Waste	Not specified.	Longitudinal, Prospective	4	27-60	Male	Maintenance Workers	Employed 1-21 years

Source		Control Group					Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Citation	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Study Duration	Was Lifestyle Questionnaire Provided to Participants?	Medium Sampled	Chemicals/ Outcome Assessed	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
111	Malkin, R., Brandt-Rauf, P., Graziano, J., and Parides, M. 1992 Environ.Res. Blood lead levels in incinerator workers	14	29-63	Unspecified	Employees in similar occupational position at heating plants.	Employed at the facility.	1 year	Yes	Blood	Pb, erythrocyte protoporphyrin	Not specified.	t-test, multiple regression, ANOVA	71	Lead levels were signficantly higher in incinerator workers than in the control group. EP levels were significantly lower in incinerator workers compared to the control group.	Lead is capable of increasing blood lead levels for workers of an incinerator relative to a control group. However, the levels observed in the study were below the acceptable occupational standards, and consistent use of PPE appears to be an effective method of preventing exposure.	Not specified.	Moderate	Moderate	Low	Moderate	No
130	Nakao, T., Aozasa, O., Ohta, S., and Miyata, H. 2005 Arch.Environ.Contam Toxicol. Survey of human exposure to PCDDs, PCDFs, and coplanar PCBs using hair as an indicator	64	Median - 38	Male	General Population - Exact meaning unspecified	Not specified.	1 year	Yes	Hair	PCDD/F, PCB	GC/MS	Unspecified	132	Workers exposed to more chemicals than general population.	Workers had exposure to a wider range of chemicals than general population. Most likely exposed in work environment, from flue gas and EP ash based on chromatographic patterns. Smokers in general population had higher concentrations of most congeners than non-smokers.	Grant-in Aid for Scientific Research	Moderate	Moderate	High	Low	No
138	Papke, O., Ball, M., and Lis, A. 1993 Chemosphere Potential occupational exposure of municipal waste incinerator workers with PCDD/PCDF	102	Unspecified.	Unspecified	Unspecified	Unspecified	Not specified.	Not specified.	Blood	PCDD/F	Not specified. Identical to previously published WHO validation study	Means calculated.	N/A	Similar congener profiles to fly ash and slag, but levels not higher than controls.	TEQ values of 10 workers did not exceed high end of TEQ range of controls. Some exceedances in individual isomers vs. control group. Similarities observed in congener patterns between workers, fly ash and slag profiles.	Not specified.	Moderate	Low	Low	Low	No
142	Raemdonck, A., Koppen, G., Bilau, M., and Willems, J. L. 2006 Archives of Environmental and Occupational Health Exposure of maintenance workers to dioxin-like contaminants during the temporary shutdown of a municipal domestic solid waste incinerator: A case series	5	27-60	Male	Maintenance Workers	Employed 1-21 years	2 years	Yes	Blood	Dioxin-Like Substances	CALUX	None	5	Results show an increase in dioxin activity at end of maintenance period vs. start. These results were not repeated in second testing period.	Data suggests a systemic exposure to molecules with dioxin-like activity, and the use of PPE may be an effective deterrent. Concentrations prior to maintenance were in the range of typical population levels in Flemish community.	External Service for Health and Prevention at Work Agathos-HD, Belgium	Very Low	Moderate	Moderate	Low	No

Source			Incinerator			Study Design	Study Group				
Ref ID	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
187	Takata, T. 2003 Ind.Health Survey on the health effects of chronic exposure to dioxins and its accumulation on workers of a municipal solid waste incinerator, rural part of Osaka Prefecture, and the results of extended survey afterwards	In September 1998 the Ministry of Health and Welfare announced that high concentrations of dioxins were detected in the samples of soil near the incinerator and ash, drainage, sludge and others remained in the furnace and air pollution control devices of municipal solid waste incinerator (MSWI) in rural part of Osaka Prefecture. According to the results the Ministry of Labor immediately organized the "Research and investigation committee on the dioxin problem of Toyono-gun Clean Center" under Japan Industrial Safety and Health Association to investigate the health effects of chronic exposure to dioxins and its accumulation on workers of the incinerator plant. The investigation was carried out in Sept 1998 and from the results, the committee concluded that the concentrations of dioxin among the blood of the workers who had engaged in maintenance of the furnace, the electric dust collector, and the wet scrubber of the incinerator were higher compared with those of residents in surrounding areas. However, there were no signs or findings correlating to blood level of dioxns, and the level was not high enough to induce sufficient health effects from the review of published papers. According to the results of this survey the committee understood that the follow-up study of blood dioxins level of group III and IV workers was inevitable and concerned about the other MSWI workers in Japan who might also be exposed to similar level of dioxins. The Ministry of Labor decided to expand the survey to other MSWI workers in Japan as 3-year project from 1999. The summarized report on the project is appended in this paper	Toyono-gun Clean Center, Western Japan	Municipal Solid Waste	Not specified.	Longitudinal, Prospective	17	Unspecified.	Unspecified	Workers - separated into 4 groups based on potential exposure.	Minimum 4 years employment in highest exposure settings (since baseline).
193	Wrbitzky, R., Goen, T., Letzel, S., Frank, F., and Angerer, J. 1995 Int.Arch.Occup.Environ.Health Internal exposure of waste incineration workers to organic and inorganic substances	One hundred and twenty-two persons employed in an industrial waste incineration plant were examined with respect to organic and inorganic substances which may be produced during the combustion of different waste. The employees were divided into three groups: persons with contact with the incinerator (WI workers, n = 45), periphery workers (n = 54) and management (n = 23). For the evaluation of internal exposure, the levels of lead, cadmium, mercury, benzene, toluene, ethylbenzene and m-xylene in blood, chromium in the erythrocytes, polychlorinated biphenyls, hexachlorobenzene and pentachlorophenol in plasma, and arsenic, chromium, nickel, vanadium, chlorophenols and hydroxypyrene in urine were determined. The internal exposures of the three groups were tested against each other and were compared with the reference values of the general population. Differences between the groups investigated were tested using the U test according to Wilcoxon, Mann and Whitney ($P < 0.05$). The biological exposure limits valid in Germany (BAT values) were not exceeded in any cases. Compared with the background levels of the German population, certain parameters were exceeded in several employees. Significantly higher levels of the WI workers in comparison to both periphery workers and management were found for toluene in blood (median: 1.1 vs 0.9 vs 0.6 microgram/l). For the lead and cadmium levels in blood and for the urinary excretion of arsenic, 2,4-dichlorophenol and tetrachlorophenols, statistical differences were found only between WI workers and one of the other groups. However, in all cases the elevations were very small and of interest more from the environmental than from the occupational point of view. It must be stressed that this waste incineration plant is very modern in terms of worker health and safety. At older plants without corresponding health and safety measures, higher internal exposure of the employees to hazardous substances may exist	Germany	Industrial Waste Incinerator	Not specified.	Cross-Sectional, Prospective	122	21-59	14 women; 108 men	Workers - plant, periphery or management	Employed in plant for 1-24 years.
196	Yoshida, J., Kumagai, S., Tabuchi, T., Kosaka, H., Akasaka, S., Kasai, H., and Oda, H. 2006 Int.Arch.Occup.Environ.Health Negative association between serum dioxin level and oxidative DNA damage markers in municipal waste incinerator workers	OBJECTIVES: To investigate the effect of dioxin on the formation of oxidative DNA damage and urinary mutagenicity, we measured the concentrations of serum dioxins and lymphocytic 8-hydroxydeoxyguanosine (8-OH-dG) in 57 male waste incinerator workers, urinary 8-OH-dG and urinary mutagenicity in 29 male waste incinerator workers. METHODS: Information about the subjects was obtained from a questionnaire. Concentrations of polychlorinated dibenzo-p-dioxin (PCDD), polychlorinated dibenzofuran (PCDF), and coplanar-polychlorinated-biphenyl (Co-PCB) in serum samples from the workers were measured with a high-resolution gas chromatograph /high-resolution mass spectrometer. Lymphocytic and urinary 8-OH-dG levels were measured with a high-performance liquid chromatography-electrochemical detector system. The urinary mutagenicity was measured with umu assay. RESULTS: The lymphocytic 8-OH-dG level showed a negative association with the serum dioxin level (total value of TEQ-PCDD, PCDF, and Co-PCB). Urinary 8-OH-dG did not show correlation with serum dioxin level, but showed positive correlation with the smoking index. CONCLUSIONS: With respect to the subjects' serum dioxin level, dioxin did not increase the urinary 8-OH-dG level by oxidative DNA damage, but upregulation of the primary defenses with oxidative damage and/or DNA repair system activity might have occurred	5 incinerators from Kinki Region, Japan	Municipal Solid Waste	Start dates range from 1973-1992. Two older plants re	Cross-Sectional, Prospective	57	Mean age - 42.2	Unspecified	Workers	Mean employment term 15.7 years

Source		Control Group					Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Citation	Number of Participants	Age of Participants	Sex of Participants	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Study Duration	Was Lifestyle Questionnaire Provided to Participants?	Medium Sampled	Chemicals/ Outcome Assessed	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
187	Takata, T. 2003 Ind.Health Survey on the health effects of chronic exposure to dioxins and its accumulation on workers of a municipal solid waste incinerator, rural part of Osaka Prefecture, and the results of extended survey afterwards	92	16-72	89 males, 3 females	Workers	All workers were employed at the time of the baseline. No indication of length of employment.	4 years	Yes	Blood	PCDD/F	GC/MS	Basic statistics - mean, SD, min, max.	109	None identified.	In baseline - no significant correlations between any lifestyle/health factors and PCDD/F levels. Levels were higher than the presented range of regular residents as determined by Japan Environment Agency. Workers working inside the facility, or in maintenance of the furnace showed the highest exposure levels. Levels not high enough to induce sufficient health effects. Follow-up study of exposed workers shows decreasing PCDD/F levels in each year for 3 years. Two other studies briefly detailed in appendix to article outlined no observable health effects due to dioxins during operations in incinerator related facilities.	Japan Ministry of Labour	Moderate	Moderate	Moderate	Low	No
193	Wrbitzky, R., Goen, T., Letzel, S., Frank, F., and Angerer, J. 1995 Int.Arch.Occup.Environ.Health Internal exposure of waste incineration workers to organic and inorganic substances	No control group - rather, reference values were determined based on toxicological properties and previously published studies.	N/A	N/A	N/A	N/A	Not specified.	Not specified.	Blood, Urine	As, Cr, Ni, V, BTEX, HCB, Chlorophenols, Hydroxypyrene, PCBs	Metals - AAS; Organics - GC	Wilcoxon, Mann-Whitney	122	None identified.	For employees of a modern facility, no relevant exposure to metals and organic compounds from an occupational-medical point of view. Compared with background levels from general population, certain parameters are exceeded but these exceedances are tolerable according to legal regulations for employees. Some significant differences between employee groups, however sample size was small.	Not specified.	Low	Low	Low	Moderate	No
196	Yoshida, J., Kumagai, S., Tabuchi, T., Kosaka, H., Akasaka, S., Kasai, H., and Oda, H. 2006 Int.Arch.Occup.Environ.Health Negative association between serum dioxin level and oxidative DNA damage markers in municipal waste incinerator workers	No control group.	N/A	N/A	N/A	N/A	2 years	Yes	Blood	PCDD/F, PCB, 8-OH-dG	GC/MS	Pearson's correlation; Spearman's correlation	57	Similar congener profiles to occupational exposure but TEQ levels in range.	Workers had high concentrations of congeners correlated with occupational exposure but TEQ levels were similar to previously published values for general population. Negative correlation of 8-OH-dG levels with dioxin levels. Based on findings, smoking habits may be more important factor of oxidative damage than dioxins.	Not specified.	Low	Low	Moderate	Moderate	No

APPENDIX C-3A

Environmental Monitoring - Included

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
3	Ambient Air	Abad, E., Caixach, J., and Rivera, J. 1997 Chemosphere PCDD/PCDF from emission sources and ambient air in northeast Spain	PCDD/PCDF were detected and quantified in emissions from municipal and industrial waste incinerators. Levels of PCDD/PCDF in ambient air were measured in order to evaluate the possible influence. Identification and quantification were carried out by HRGC/HRMS with isotopic dilution as a quantification method using two different GC columns: J&W DB-5 and J&W DB-DIOXIN	Catalonia, Spain	Industrial and Municipal Waste	N/A	Cross Sectional	Ambient Air: n=21	Ambient Air	Sampling sites either in the area or under the influence of the industrial incinerators or the municipal waste incinerators (no actual distances	High traffic and industrial influence at one site	Ambient Air: 14	Ambient Air	Urban air and urban air with high traffic influence (no distances from the incinerator given)	High traffice influence at one site
6	Ambient Air	Agrell, C., Ter Schure, A. F. H., Sveder, J., Bokenstrand, A., Larsson, P., and Zegers, B. N. 2004 Atmospheric Environment Polybrominated diphenyl ethers (PBDES) at a solid waste incineration plant I: Atmospheric concentrations	In the first of two papers, the atmospheric poly brominated diphenyl ether (PBDE) concentrations at a municipal solid waste incineration (MSW) plant with electronic recycling is compared with that at an industrial urban reference site producing asphalt and concrete. In the second paper, atmospheric deposition and washout behaviour is presented (Atmos. Environ. (2004a)). PBDEs (BDE28, -47, -66, -100, -154, -153, -183, -209) in the gaseous and particulate phase were measured with high resolution in time during the colder parts of the year to minimise the influence of potential historical pollution at the sites through volatilisation. This also means that reported levels are lower compared to other reported data. Results of BDE47 (TetraBDE) and BDE209 (DecaBDE) as representatives of "old" vs. "new" PBDEs as well as [summation sign]PBDE, excluding BDE209, are presented. Median [summation sign]PBDE, BDE47 and BDE209 concentration were 6.3, 2.1 and 10.4pgm⁻³ at the MSW and 3.5, 1.7 and 6.5pgm⁻³ at the reference site. The total concentrations (gaseous and particulate phase) were significantly higher at the MSW compared to the reference site for [summation sign]PBDE and BDE47 but not for BDE209. The same results were obtained regarding concentrations in the gaseous phase. Particle concentrations were significantly higher at the MSW for [summation sign]PBDE, BDE47 and BDE209. Within each site, the gaseous-phase concentration was significantly higher than the particulate-phase concentration except for BDE209 at the MSW. Thus, the proportion of BDE209 detected in the particulate phase was higher at the MSW compared to the reference site. Together with the results of the second paper, we suggest that treatment of waste is presently a source of "old" PBDEs to the environment, whereas the rather similar BDE209 concentrations at the two sites are more a result of proximity to potential diffuse sources.	Malmo, Sweden	Municipal Waste	Not specified	Longitudinal	Ambient Air: n=unspecified	Ambient Air	Samples were taken at 2 sites near the MWI	Other industrial and urban sources	Ambient Air: n=unspecified	Ambient Air	Samples were taken at a rural reference site	None Specified
16	Ambient Air	Besombes, J. L., Maitre, A., Patissier, O., Marchand, N., Chevron, N., Stoklov, M., and Masclet, P. 2001 Atmospheric Environment Particulate PAHs observed in the surrounding of a municipal incinerator	An intensive sampling campaign was undertaken in the surroundings of a municipal waste incinerator located in a French great urban centre in order to evaluate the impact of particles emissions on the ambient air and to estimate the exposure levels to toxic or carcinogenic compounds for a population living in the neighbourhood of this incinerator. To minimise the effect of industrial and road activities, sampling was performed during the 2 days of a weekend and on Monday morning. Different operating modes of the incinerator were investigated: (i) normal incinerator functioning and (ii) maintenance activity of the combustion chamber corresponding to the stop and cooling furnace periods. Particulate polycyclic aromatic hydrocarbons (PAHs) and total particulate carbon concentrations were determined in three sites situated, respectively, close to the incinerator, 2km downwind and 1km upwind of the plant. In normal operating mode similar concentrations were observed in the three sites. During the furnace stop an increase of total PAH concentrations was observed in the sampling site close to the incinerator. The concentration was 3 times higher than those measured in the other two sampling sites. But this increase was limited in time and in space since this phenomenon is only observed in the vicinity of the incinerator. The study of PAH profiles indicated that Pyrene and Retene showed the highest enhancement of their relative concentrations. The influence of incinerator functioning parameters on the PAHs concentrations is discussed. The furnace temperature and the mode of exhaust fumes seem to be deciding parameters to	Large urban area, France	Municipal Waste	N/A	Cross Sectional, Prospective	Ambient Air: n=14	Ambient Air	Site B was located less than 10 meters from the incinerator Site C was located about 2300 meters from the incinerator	None Specified	Ambient Air: n=7	Ambient Air	Site A was located about 1000 meters upwind from the incinerator	None Specified
17	Lakebed sediment; Vegetation; Snow	Blais, J. M., Froese, K. L., Kimpe, L. E., Muir, D. C., Backus, S., Comba, M., and Schindler, D. W. 2003 Environ.Toxicol.Chem. Assessment and characterization of polychlorinated biphenyls near a hazardous waste incinerator: analysis of vegetation, snow, and sediments	Samples of spruce needles, snowpack, and sediment were analyzed in the area around the Alberta Special Waste Treatment Centre (ASWTC) near Swan Hills, Canada, in 1997 and 1998, following a major accidental release of polychlorinated biphenyls (PCBs) and polychlorinated dibenzo-p-dioxins and furans (PCDD/Fs) in October 1996. The PCB concentrations in spruce needles and snow were mostly elevated to the east of the plant and contained congeners that were not present at upwind or distant sites. Several years of annual vegetation monitoring data indicated that PCB emissions increased prior to the reported accident. Within 3 km of the plant, there was a predominance of higher chlorinated congeners penta-, hexa-, hepta-, and octachlorobiphenyls in white spruce (Picea glauca) needles and snow. Polychlorinated biphenyl congener patterns varied seasonally in spruce needles, likely influenced by temperature effects on the volatilization and of particle-bound and vapor phase PCBs in the forest canopy. The similarity of deposition patterns in snow and needles in 1997 and 1998 suggested the PCBs in the surrounding area were derived by long-term fugitive releases of PCBs rather than an accidental release. In addition, hexachlorobenzene, a combustion by-product of chlorinated organics in waste incinerators, was not measured at elevated concentrations in spruce needles or snow east of the facility and, when detected, was not correlated with PCB concentrations. A radiometrically dated sediment core from nearby Chrystina Lake (AB, Canada) showed a gradual increase in annual PCB flux during the early years of operation of	Swan Hills, Alberta	Hazardous Waste	1987	Longitudinal, Prospective	Snow: 28 (18 in 1997; 10 in 1998) Vegetation: not specified Sediments: not specified	Snow Vegetation (White spruce needles and lichen growing on spruce) Core sediments from Chrystina Lake	Samples were collected within 25kms from the HWI	None Specified	Snow: not specified Vegetation: not specified	Snow Vegetation (White spruce needles and lichen growing on spruce)	Samples used as control were distant and upwind of the HWI	None Specified

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
3	Ambient Air	Abad, E., Caixach, J., and Rivera, J. 1997 Chemosphere PCDD/PCDF from emission sources and ambient air in northeast Spain	Not specified	PCDD/F concentrations	High volume air sampler	Not elaborated.	HRGC/HRMS	Basic Statistical analysis and isomer profiles	Ambient Air: 35	Yes, the profiles of ambient air assumed to be influenced by the incinerator matched the stack gas profiles.	The profiles of ambient air sampled from areas assumed to be influenced by incinerators present the same aspect as stack emissions. Further improvements in the pas cleaning systems should greatly reduce the total amount of PCDD/F released into the atmosphere. In other areas traffic and a chemical plant were	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
6	Ambient Air	Agrell, C., Ter Schure, A. F. H., Sveder, J., Bokenstrand, A., Larsson, P., and Zegers, B. N. 2004 Atmospheric Environment Polybrominated diphenyl ethers (PBDES) at a solid waste incineration plant I: Atmospheric concentrations	6 months	Polybrominated diphenyl ethers (PBDE) concentrations	High volume air sampler with PUFs and filters	Samples were stored on the filters and frozen until analysis	GC/MS	paired t-tests and basic statistical analysis	Ambient Air= unspecified	Yes concentrations of some PBDEs were significantly higher near the MWI than the reference sites	The total concentrations (gaseous and particulate phase) were significantly higher at the MSW compared to the reference site for PBDE and BDE47 but not for BDE209. The same results were obtained regarding concentrations in the gaseous phase. Particle concentrations were significantly higher at the MSW for PBDE, BDE47 and BDE209. Within each site, the gaseous-phase concentration was significantly higher than the particulate-phase concentration except for BDE209 at the MSW. Thus, the proportion of BDE209 detected in the particulate phase was higher at the MSW compared to the reference site. Together with the results	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
16	Ambient Air	Besombes, J. L., Maitre, A., Patissier, O., Marchand, N., Chevron, N., Stoklov, M., and Masclet, P. 2001 Atmospheric Environment Particulate PAHs observed in the surrounding of a municipal incinerator	3 days	PAH and carbon concentrations	Glass fiber filters	After sampling all filters were stored in aluminum foil within a heat-sealed polyethylene bag, kept frozen in the dark until chemical analysis	Spectra Physic 8800 chromatograph and a Perkin-Elmer LC 240 detector	Multivariate analysis	Ambient Air: 21	PAH levels in the immediate area of the MWI could be attributed to the MWI	PAH emissions depend on the incinerator functioning modes. At normal operations the PAH emissions are negligible (similar to controls), during the furnace cooling and unstable combustion the PAH emissions rose in areas close to the MWI. No matter the operating conditions the impact on the ambient air in weak compared with the PAH concentrations induced by the industrial and road activities.	ADEME	Moderate	Moderate	Moderate	Moderate	Yes
17	Lakebed sediment; Vegetation; Snow	Blais, J. M., Froese, K. L., Kimpe, L. E., Muir, D. C., Backus, S., Comba, M., and Schindler, D. W. 2003 Environ.Toxicol.Chem. Assessment and characterization of polychlorinated biphenyls near a hazardous waste incinerator: analysis of vegetation, snow, and sediments	2 years	PCB concentrations	Vegetation: collected in polyethelene Whirl-Pak bags Snow: double wrapped in clean polyethelene bags Sediments: Glew gravity corer	Vegetation: stored at -50C Snow: frozen in polyethylene bags Sediments: stored as cores	GC/MS	Multivariate analysis, power analysis	Snow: 28 (18 in 1997; 10 in 1998) Vegetation: not specified Sediments: not specified	Yes levels of PCBs in environmental media were assumed to be from the HWI	The similarity of deposition patterns in snow and needles in 1997 and 1998 suggested the PCBs in the surrounding area were derived by long-term fugitive releases of PCBs rather than an accidental release. In addition, hexachlorobenzene, a combustion by-product of chlorinated organics in waste incinerators, was not measured at elevated concentrations in spruce needles or snow east of the facility and, when detected,	Canada and Natural Sciences and Engineering Research Council	Moderate	Moderate	Moderate	Moderate	Yes

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
18	Ambient Air	Blanch, A. and Bianchi, A. C. 1999 Atmospheric Environment Volatile organic compounds in an urban airborne environment adjacent to a municipal incinerator, waste collection centre and sewage treatment plant. AU - LEACH J	Biosis copyright: Biol abs. The occurrence and temporal distribution of airborne volatile organic compounds (Voc) At nine closely grouped locations in a suburban environment on the edge of the coastline of the southampton water estuary, located on the coastline of central southern england, was studied over six monthly periods spanning 1996-1997. The sampling sites circumscribed a juxtaposed municipal incinerator, waste collection and processing centre and sewage treatment plant. Three sets of airborne samples being taken b essing operations on atmospheric voc within the local environment. The most abundant voc classes consisted of aromatic, chlorinated and organosulphide compounds, with smaller proportions of alkanes, alkenes and cycloalkane compounds. Compounds produced by sewage-processing and waste management operations, including volatile organosulphides and various oxygenated compounds, may occasionally exceed olfactory detection thresholds and represent a source of potential odour complaints in the local urb	Southampton, Southern England	Municipal Waste	N/A	Longitudinal	Ambient Air: n=27	Ambient Air	Ambient Air stations were set up at 9 locations ranging from 75 meters to 300 meters from the MWI	None Specified	Ambient Air: n=27	Ambient Air	Ambient Air stations were set up at 9 locations ranging from 75 meters to 300 meters from the MWI	None Specified
20	Vegetation; Fauna	Bocio, A., Nadal, M., and Domingo, J. L. 2005 Biological Trace Element Research Human exposure to metals through the diet in Tarragona, Spain: temporal trend	The concentrations of arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), mercury (Hg), manganese (Mn), nickel (Ni), lead (Pb), tin (Sn), thallium (Tl), and vanadium (V) were determined in a number of food items purchased in zones of Tarragona County (Catalonia, Spain) near a hazardous waste incinerator (HWI), which has been operating since 1999. Food samples corresponded to the following groups: meat, fish and seafood, pulses, cereals, vegetables, fruits, tubers, whole milk, yogurt, eggs, and sugar. Be and Tl were under their respective limits of detection in all samples. For the analyzed trace elements, the dietary intake by the general population of Tarragona was 458.5 microg/d for As, 14.3 microg/d for Cd, 88.3 microg/d for Cr, 5.3 microg/d for Hg, 2421.4 microg/d for Mn, 138.3 microg/d for Ni, 44.8 microg/d for Pb, 34.6 microg/d for Sn, and 28.9 microg/d for V. Results were compared with those found in a baseline survey carried out in the same area during the construction of the HWI (1996-1998). In general terms, the dietary intake of metals in 2003 was comparatively similar to those found in the baseline survey. For the most toxic elements (As, Cd, Hg, and Pb), it was under their respective Provisional Tolerable Weekly Intake (PTWI) established by the FAO/WHO	Tarragona, Spain	Hazardous Waste	1999	Longitudinal, Prospective	360	Meat, fish and seafood, pulses, cereal, vegetables, tubers, fruits, whole milk, dairy products, eggs and sugar.	In the same county as the incinerator.	None identified.	Baseline survey completed in prior study.	Meat, fish and seafood, pulses, cereal, vegetables, tubers, fruits, whole milk, dairy products, eggs and sugar.	In the same county as the incinerator.	No
22	Ambient Air	Bolt, A. and De Jong, A. P. J. M. 1993 Chemosphere Ambient air dioxin measurements in the Netherlands	Preliminary results of a survey programme for airborne PCDD/F demonstrate that present sampling and analysis techniques allow the determination of low fg/m³ of polychlorinated dibenzodioxins (PCDDs) and dibenzofurans (PCDFs) in ambient air. Sampling recoveries of PCDD/Fs added to the filter before sampling gave recoveries of 75 +/- 10% on average, and was found the preferred method for reliable quantification under field conditions. Particulate bound PCDD/F levels in air in a municipal waste incinerator deposition area ranged between 15 +/- 5 and 125 +/- 25 fg TCDD toxicity equivalents/m³ (International TEQ), the high values found in downstream air masses. The local background level was estimated at a value of 10-15 fg TEQ/m³. Congener profiles were very similar in all wind directions and compared well with that found in MSW emissions	The Netherlands	Municipal Waste	N/A	longitudinal	Ambient Air: Unspecified	Ambient Air	Various wind directions ar a distance of about 10km NE from the inicnerator	None Specified	Ambient Air: unspecified	Ambient Air	Rural area of unspecified distance	None Spacified
26	Ambient Air; Soil	Caserini, S., Cernuschi, S., Giugliano, M., Grosso, M., Lonati, G., and Mattaini, P. 2004 Chemosphere Air and soil dioxin levels at three sites in Italy in proximity to MSW incineration plants	Levels of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in both air and soil samples were measured at three different sites in Italy, in proximity to three municipal solid waste incinerators (MSWIs) to determine baseline contamination and the contributory role of incinerator emissions. At the first site, located in an agricultural, cattle-breeding, typically flattish area of the Po Valley, the dioxin concentrations had already been measured before the start-up of the new MSWI. These dioxin concentrations were then again measured after two years of continual operation of the incinerator. Despite the presence of the plant, the PCDD/Fs concentrations appear not to have been affected and were found to be in a range of 22-125 fg I-TEQ m(-3) in the air samples and 0.7-1.5 pg I-TEQ g(-1) in the soil samples. The second site is located in an industrial district of the Veneto Region, in the surroundings of an old MSWI that is not equipped with Best Available Technology (BAT) dioxin removal system. The PCDD/Fs concentrations in the air samples were between 144 and 337 fg I-TEQ m(-3). This is a typical range of values for industrial areas, while the soil samples showed contamination levels between 1.1 and 1.4 pg I-TEQ g(-1). The third site lies in the Adige Valley, near a MSWI that has been equipped with BAT for flue gas cleaning. The observed values ranged from 10 to 67 fg I-TEQ m(-3) for the air samples and 0.08-1.2 pg I-TEQ g(-1) for the soil samples. The contributory factors of the varying characteristics of the different areas together with the types of technology adopted at each MSWI plant are discussed. The PCDD/Fs levels are subsequently compared with established values from previous studies	Site 1: Po Valley, Italy Site 2: Veneto Region, Italy Site 3: Adige Valley, Italy	Municipal Waste	Site 1: 1998 Site 2: 1983 Site 3: 1994	Cross Sectional	Ambient Air: 12 Soil: 9	Ambient Air and Soil Samples	Air and Soil: Site 1: 750m - 5000m Site 2: 750m - 2000m Site 3: 1500m - 3000m	Traffic and industrial sources present at some sites	Ambient Air: 3 Soil: 3	Ambient Air and Soil Samples	Air and Soil Site 1: 6000m Site 2: 3000m Site 3: 10,000m	None Specified

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
18	Ambient Air	Blanch, A. and Bianchi, A. C. 1999 Atmospheric Environment Volatile organic compounds in an urban airborne environment adjacent to a municipal incinerator, waste collection centre and sewage treatment plant. AU - LEACH J	2 years	VOCs	Perkin Elmer stainless steel adsorbent tubes	All samples were collected, sealed with Swagelok end caps and returned to the laboratory for analysis in sealed, precleaning glass jars, and stored in a sampled refrigerator at 4 ^{0}C	HRGC/HRMS	Basic Statistical analysis	Ambient Air: 54	Yes, concentrations in the sampling sites closest to the MWI decreased after the incinerator closed.	More than 100 VOC's were typically identified in the ambient air samples. VOC concentrations were reduced approx 50% after the MWI closed. Volatile organosulphides were found at levels which may represent a source of odor complaints in the vicinity.	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
20	Vegetation; Fauna	Bocio, A., Nadal, M., and Domingo, J. L. 2005 Biological Trace Element Research Human exposure to metals through the diet in Tarragona, Spain: temporal trend	4 years	As, Be, Cd, Cr, Hg, Mn, Ni, Pb, Sn, Tl, V	Not elaborated.	Not elaborated.	ICP/MS	Mann-Whitney U-test	360	No correlation.	No notable differences between current survey and baseline. Shows the absence of a measurable health impact on the population.	Not discussed.	High	Moderate	High	Moderate	Yes
22	Ambient Air	Bolt, A. and De Jong, A. P. J. M. 1993 Chemosphere Ambient air dioxin measurements in the Netherlands	7 months	PCDD/F concentrations	High volume air sampler with glass fiber filters	Not elaborated	GC/MS	Congener profile analysis	unspecified	Congner profiles in ambient air and incerator fly ask were in good agreement, indicating that MWI was a source for PCDD/Fs in ambient air	Particulate bound PCDD/F levels in air in a municipal waste incinerator deposition area ranged between 15 +/- 5 and 125 +/- 25 fg TCDD toxicity equivalents/m³ (International TEQ), the high values found in downstream air masses. The local background level was estimated at a value of 10-15 fg TEQ/m³. Congener profiles were very similar in all wind directions and compared well with that found in MSW emissions	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
26	Ambient Air; Soil	Caserini, S., Cernuschi, S., Giugliano, M., Grosso, M., Lonati, G., and Mattaini, P. 2004 Chemosphere Air and soil dioxin levels at three sites in Italy in proximity to MSW incineration plants	4 years	PCDD/F concentrations	Ambient Air: high-volume air samplers with glass fiber filters and PUF plugs Soil: metal hand operated sampling tool	Ambient Air: cleaned glass and polyethylene boxes Soil: sieved	HRGC/HRMS	Basic statistical analysis and Principal Component Analysis	Ambient Air: 15 Soil:12	Site 1: MWI not affecting air and soil concentrations Site 2: MWI in addition to other industrial sources affecting air and soil concentrations Site 3: low dioxin levels resulting from abatement technologies and limited industrial activity in the area	Atmospheric concentrations are comparable to other studies conducted on PCDD/F contamination. Site 2 had the highest levels of PCDD/F contamination. This is a result of poor pollution abatement and high levels of industrial activity	AEM Cremona, and the Municipality of Bolanzo	Moderate	Moderate	Moderate	Moderate	Yes

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
28	Ambient Air	Chang, M. B., Weng, Y. M., Lee, T. Y., Chen, Y. W., Chang, S. H., and Chi, K. H. 2003 Chemosphere Sampling and analysis of ambient dioxins in northern Taiwan	In this study, ambient air samples were taken concurrently in the vicinity area of a large-scale municipal waste incinerator (MWI) and the background area for measuring polychlorinated dibenzo-p-dioxins and furans (PCDD/Fs) concentrations from November 1999 through July 2000 in northern Taiwan. The results obtained from eighteen ambient air samples indicate that the mean PCDD/F concentration of seventeen 2,3,7,8-substituted congeners in wintertime (188-348 fg-I-TEQ/m(3)) is significantly higher than that measured in summertime (56-166 fg-I-TEQ/m(3)). In addition, the seasonal PCDD/F concentrations are compared with the ambient air quality data including CO, NO(2), PM(10) and TSP sampled from Taipei area to gain better insights. It indicates that the variation of ambient air PCDD/F concentrations is closely correlated with that of PM(10) concentrations. Besides, the results indicate that the I-TEQ concentration of ambient air in sampling site B (directly downwind of the MWI) is of the highest while the sampling site A (upwind of MWI) is of the lowest among all sampling sites. This implies that existing MWI can be a significant emitter of PCDD/Fs in this area. Furthermore, the patterns of the PCDD/F congener distribution at all sampling sites (including the background site in Taoyuan) are quite similar. OCDD concentration is of the highest among seventeen PCDD/F congeners investigated and accounts for about 35% of the total concentration. As for the I-TEQ concentrations, 2,3,4,7,8-PeCDF is the most significant contributor, generally being responsible for 30-45% of the total I-TEQ values	Nothern Taiwan	Municipal Waste	1995	Longitudinal	Ambient Air: n=14	Ambient Air	Samples were taken within the depositional ranges of the MWI. 1.4 to 3.1 kms from the MWI	None Specified	Ambient Air: n=4	Ambient Air	Samples were taken from an area not in the depositional ranges of the MWI	None Specified
36	Soil	Collett, R. S., Oduyemi, K., and Lill, D. E. 1-19-1998 Sci.Total Environ. An investigation of environmental levels of cadmium and lead in airborne matter and surface soils within the locality of a municipal	The results of an investigation into the environmental impact of heavy metals in the airborne emissions from the Baldovie municipal waste incinerator, Scotland, are presented. A sampling network of 1-km grid squares covering a 7 x 9 km area was established over the incinerator plant and its surroundings. Surface soil core samples were collected from within each 1 km2 and analysed for cadmium and lead content. The spatial distribution of lead levels in soils showed a marked variation downwind from the Baldovie incinerator in comparison with the background level for the area but remained well within the typical range of lead in rural, unpolluted, British soils. A comparison of the observed levels of lead in local soils, with the predicted downwind long-term ground level lead distribution in air indicates that atmospheric emissions of lead originating from the Baldovie incinerator directly determine concentrations of lead in soils within a	Dundee, Scotland	Municipal Waste	N/A	Cross Sectional	Soil: n=10	Soil	1km to 5 kms from the MWI	None Specified	background soil used but not elaborated	Soil (but not described)	Not specified	Not specified
39	Ambient Air	Coutinho, M., Pereira, M., Rodrigues, R., and Borrego, C. 6-1-2006 Sci.Total Environ. Impact of medical waste incineration in the atmospheric PCDD/F levels of Porto, Portugal	As a consequence of a monitoring program of a new municipal waste incinerator initiated in 1998, a large data-base of dioxin and furan concentrations in the atmosphere of the metropolitan area of Porto, in northern Portugal, has been collected. The existence of this data coincides with the shutdown in January 2001 of two medical waste incinerators that were under operation in the inner city of Porto. Dioxin emissions from these facilities were measured indicating emissions 100 to 1000 times larger than recent European Union directive limits. Data show that the shutdown of these two units had a clear effect on the improvement of air quality in the region that was observed either on the overall level of dioxins and furans or as in subtle alterations of the homolog pattern of these compounds in the atmosphere	Porto, Portugal	2 Medical Waste Incinerators	1998	Longitudinal	Ambient Air: n=unspecified	Ambient Air	Samples were taken within an unspecified radius (best estimation: within 15kms from the MWIs)	None Specified	Ambient Air: unspecified	Ambient Air	Samples were taken within an unspecified radius (best estimation: within 15kms from the MWIs)	None Specified
41	Worker Ambient Air	Crandall, M. S., Kinnes, G. M., and Hartle, R. W. 1992 Chemosphere Levels of Chlorinated Dioxins and Furans in Three Occupational Environments	Measurements of chlorinated dibenzo-p-dioxins (CDD) and chlorinated dibenzofurans (CDF) in three different occupational environments were made by NIOSH. Air sampling to determine potential inhalation exposures to CDD and CDF were conducted at a municipal incinerator in Philadelphia, Pennsylvania, an electrical transformer metals reclamation facility in Ashtabula, Ohio, and a paper mill in Rumford, Maine. Additionally, the potential for skin exposure was determined by collecting surface wipe samples for CDD and CDF from the incinerator and metals reclamation facility. The municipal incinerator CDD toxic equivalent airborne concentrations ranged from 0.01 to 20.4 picograms/cubic meter (pg/m3), and the CDD/CDF toxic equivalent surface concentrations ranged from 0.4 to 43.5pg/m3. CDD/CDF airborne concentrations at the metals reclamation facility ranged from 0.1 to 6.2pg/m3, and surface toxic equivalents were between 2.7 and 36.1pg/m3. The paper mill had CDD/CDF toxic equivalents ranging from 0.01 to 0.06pg/m3. The authors conclude that potential inhalation exposures to both CDD and CDF measured at the metals reclamation facility and the incinerator are near or more than the National Research Council (NRC) guideline of 10pg/m3. Surface levels of CDD and CDF are also above the NRC guideline of 25pg/m3, indicating that skin exposure is probable	Philadelphia, PA, USA	Municipal Waste	N/A	Cross Sectional	Air Samples: n=4 Surface Samples: n=4	Ambient Air samples and Surface Wipe Samples	Ambient Air: incinerator cleaning, incinerator central, Southside ash pile, north side ash pile, Surface samples: incinerator area floor, lunchroom tabletop, change room bench, office	None Specified	Air Samples: n=1 Surface Samples: n=1	Ambient Air and Surface Samples	Ambient Air: residential area Surface Samples: Hotel	None Specified
45	Soil	Demond, A., Adriaens, P., Towey, T., Chang, S. C., Hong, B., Chen, Q., Chang, C. W., Franzblau, A., Garabrant, D., Gillespie, B., Hedgeman, E., Knutson, K., Lee, C. Y., Lepkowski, J., Olson, K., Ward, B., Zwica, L., Luksemburg, W., and Maier, M. 8-1-2008 Environ.Sci.Technol. Statistical comparison of residential soil concentrations of PCDDs, PCDFs, and PCBs from	The University of Michigan dioxin exposure study was undertaken to address concerns that the industrial discharge of dioxin-like compounds in the Midland, MI area had resulted in contamination of soils in the Tittabawassee River floodplain and downwind of the incinerator. The study was designed in a rigorously statistical manner comprising soil measurements of 29 polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and polychlorinated biphenyls (PCBs) from 766 residential properties, selected probabilistically, in the Midland area and in Jackson and Calhoun Counties (Michigan) as a background comparison. A statistical comparison determined that the geometric mean toxic equivalent (TEQ) levels in samples from the target populations were statistically significantly above background. In addition, the probabilities of being above the 75th and 95th percentiles of background were also greater. Congener contributions to the TEQ were dominated by 2,3,4,7,8-PeCDF and 2,3,7,8-TCDF in the floodplain and by 2,3,7,8-TCDD in the incinerator plume. However, PCB 126 was the top congener contributing to the background TEQ. On the basis of statistical inference to the total population, it was estimated that about 36% of the properties in the floodplain and incinerator plume have at least one soil sample over the Michigan Department of Environmental Quality's soil direct contact criterion of 90 pg/g TEQ	Midland, Michigan, USA	Chemical Incinerator	N/A	Cross Sectional	Soil Samples: n=2185	Soil Samples	Samples were taken in areas located in the incinerator plume, the floodplain, near floodplain, Midland/Saginaw area	None Specified	Soil Samples: n= 371	Soil Sample	Jackson/Calhoun Counties	None Specified

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
28	Ambient Air	Chang, M. B., Weng, Y. M., Lee, T. Y., Chen, Y. W., Chang, S. H., and Chi, K. H. 2003 Chemosphere Sampling and analysis of ambient dioxins in northern Taiwan	9 Months	PCDD/F concentrations	High volume air sampler with PUFs and filters	Samples were stored in a refrigerator until analysis	GC/MS	TEQ calculations and basic statistical analysis	Ambient Air: 18	Yes PCDD/F concentrations were higher in samples downwind and in close proximity to the MWI	PCDD/F concentrations are higher in the wintertime than in the summer. The results indicate that the I-TEQ concentration of ambient air in sampling site B (directly downwind of the MWI) is of the highest while the sampling site A (upwind of MWI) is of the lowest among all sampling sites. This implies that existing MWI can be an emitter of PCDD/Fs in this area. Furthermore, the patterns of the PCDD/F congener distribution at all sampling	National Science Council of the Republic of China	Moderate	Moderate	Moderate	Moderate	Yes
36	Soil	Collett, R. S., Oduyemi, K., and Lill, D. E. 1-19-1998 Sci.Total Environ. An investigation of environmental levels of cadmium and lead in airborne matter and surface soils within the locality of a municipal	Not specified	Pb and Cd	Not elaborated.	Soil samples were sieved and dried prior to analysis. Storage not elaborated	Atomic absorption spectroscopy	Basic statistical analysis (mean, s.d)	Soil: 10	Yes, contamination within the immediate area was attributed to the MWI	A comparison of the observed levels of lead in local soils, with the predicted downwind long-term ground level lead distribution in air indicates that atmospheric emissions of lead originating from the Baldovie incinerator directly determine concentrations of lead in soils	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
39	Ambient Air	Coutinho, M., Pereira, M., Rodrigues, R., and Borrego, C. 6-1-2006 Sci.Total Environ. Impact of medical waste incineration in the atmospheric PCDD/F levels of Porto, Portugal	6 years	PCDD/F concentrations	Ambient Air: high volume air samplers	Samples were stored on filters	HRGC/HRMS	PCA and basic statistical analysis	Ambient Air: unspecified	Data shows a significant reduction in atmospheric PCDD/F concentrations after the closure of the 2 medical waste incinerators	Dioxin emissions from these facilities were measured indicating emissions 100 to 1000 times larger than recent European Union directive limits. Data show that the shutdown of these two units had a clear effect on the improvement of air quality in the region that was observed either on the overall level of dioxins and furans or as in subtle alterations of the homolog pattern of these compounds in the atmosphere	LIPOR, Portugal	Moderate	Moderate	Moderate	Moderate	Yes
41	Worker Ambient Air	Crandall, M. S., Kinnes, G. M., and Hartle, R. W. 1992 Chemosphere Levels of Chlorinated Dioxins and Furans in Three Occupational Environments	1 year	PCDD/F concentrations	Air Samples: two stage air sampler with glass filter and glass cartridge containing right grams of silica gel absorbent Surface Samples: collected using 3"x 3" Soxhlet-extracted cotton gauze pads wetted with 8ml of pesticide-grade hexane.	Not elaborated.	GC/MS	TEQ concentrations	Ambient Air: 5 Surface Samples: 5	Yes, chemical concentrations were assumed to be from the incinerator	Although the majority of levels were low, potential inhalation (air) exposures to PCDD/F were measured at the incinerator (respirators were worn so exposure is reduced). Potential surface exposure was also seen as one level was above the 25 ng/m2 threshold.	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
45	Soil	Demond, A., Adriaens, P., Towey, T., Chang, S. C., Hong, B., Chen, Q., Chang, C. W., Franzblau, A., Garabrant, D., Gillespie, B., Hedgeman, E., Knutson, K., Lee, C. Y., Lepkowski, J., Olson, K., Ward, B., Zwica, L., Luksemburg, W., and Maier, M. 8-1-2008 Environ.Sci.Technol. Statistical comparison of residential soil concentrations of PCDDs, PCDFs, and PCBs from	Unspecified	PCB and PCDD/F concentrations	custom-made, 1inch (inside diameter) polycarbonate sample tubes driven into the ground using a slide hammer	Not elaborated.	HRGC/HRMS	*T*-Test, Wald chi-square test	Soil samples: 2185 Soil samples (control): 371	Not explicitly stated that the chemical incinerator is the main source of PCDD/F contamination. Stack gas and soil not compared.	Researchers determine that the geometric mean soil concentrations in all 4 areas in Modland, Saginaw, and Bay Counties, not just the floodplain and the incinerator plume in the city of Midland, were elevated relative to background soil samples.	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
57	Fauna	Eitzer, B. D. 1995 Chemosphere Polychlorinated dibenzo-p-dioxins and dibenzofurans in raw milk samples from farms located near a new resource recovery incinerator	Bovine milk samples were taken from farms near a new resource recovery incinerator both before and one year after the incinerator went into operation. These samples were analyzed for 2,3,7,8-substituted polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans using liquid-liquid extraction, a semi-automated clean-up procedure and high resolution gas chromatography/high resolution mass spectrometry. No significant differences were observed between the PCDD/F concentrations in the pre-operational and post-operational samples	Conneticut, USA	Municipal Waste	1992	Longitudinal	Bovine Milk samples: n=12	Bovine Milk Samples	Farms were located between 2 and 8 miles from the incinerator	None specified (though farms are downwind of the industrial NYC area approx 160kms to the West)	Bovine Milk Sample: n=17	Bovine Milk	Farms were located between 2 and 8 miles from the incinerator	None specified (though farms are downwind of the industrial NYC area approx 160kms to the West)
62	Soil	Feng, Y. and Barratt, R. 1999 J.Environ.Monit. Distributions of lead and cadmium in dust in the vicinity of a sewage sludge incinerator	The content of lead and cadmium in surface dust within a 4 km radius of a sewage sludge incinerator has been investigated. Particular attention was given to Pb and Cd in different size fractions of dust, an aspect not explored in previous studies, and the differences between expressions of contamination as concentration or loading were examined. Despite suggestions from reports that sludge incinerators may have difficulty in complying with emission standards, the present investigation found little evidence for a major contribution to local pollution by the incinerator. Certainly, the highest Cd level was found some 2.2 km downwind of the prevailing wind direction from the incinerator, suggesting some resultant contamination, although the levels do not appear to be excessive. Similar observations apply to Pb contamination of the area. While data of the type produced in this study contribute to an understanding of environmental quality, both loadings and levels need to be considered, as the implications of only consideration one of these may be limited and even misleading	Coleshill (near Birmingham)	Sewage Sludge Incinerator	1976	Cross Sectional	Surface Ground Dust: n=22	Surface Ground Dust	Samples were collected within 4kms from the Incinerator	None specified	Surface Dust Samples: n=1	Surface Dust Samples	Unsure (actual location is not stated)	None Specified
63	Soil; Vegetation	Ferre-Huguet, N., Nadal, M., Mari, M., Schuhmacher, M., Borrajo, M. A., and Domingo, J. L. 2007 Bull.Environ.Contam Toxicol. Monitoring metals near a hazardous waste incinerator. Temporal trend in soils and herbage	In recent years, incineration has been demonstrated to be a commercially available technology for hazardous waste (HW) disposal (Richter and Johnke, 2004). However, because of the potential adverse effects of toxic emissions, waste incinerators are still an important cause for concern for the public. In spite of that, compliance with current EU emissions has vastly reduced the probability of adverse health effects (Glorennec et al., 2005). With respect to metals, a number of studies have shown that these elements are emitted by industrial, medical and municipal waste incinerators (Schumacher et al., 1997; Rimmer et al., 2006). Filter ash is an especially problematic residue because it contains high metal concentrations (Lisk et al., 1989). After combustion in modern HW incinerators (HWIs), metals contained in HW are mainly collected in bottom and fly ash, with only small quantity of metals being discharged from the stack as particulate matter or vapor (Jung et al., 2004). However, the atmospheric emission of these elements is a matter of concern	Tarragona, Spain	Hazardous Waste	1998	Longitudinal, Prospective	Soil: n=40 Herbage: n=40 (30 rural areas, 10 urban areas)	Soil: topsoil bulk samples representing an area of approx $1m^2$ at each sampling site. Herbage: *pipatherum paradoxum* were collected 5cm from the soil.	samples were collected within 8km from the HWI	None Specified	See Ref ID 35 for baseline data	N/A	N/A	N/A
80	Soil	Jimenez, B., Eljarrat, E., Hernandez, L. M., Rivera, J., and Gonzalez, M. J. 1996 Chemosphere Polychlorinated dibenzo-p-dioxins and dibenzofurans in soils near a clinical waste incinerator in Madrid, Spain. Chemometric comparison with other pollution sources and soils	Surface soils samples (0-5 Cm) Collected in the surroundings of a clinical waste incinerator (Cwi) Were analysed for polychlorinated dibenzo-p-dioxins (Pcdds) And dibenzofurans (Pcdfs). Pcdds and pcdfs were found at ppt levels at the 16 points sampled. The analytical data obtained reflect a slight contamination by pcdds in the area studied, but do not clarify whether the cwi plant is the only pcdd/f source responsible for that contamination. The pcdd/f patterns and profiles from the investigated sods were compared chemometrically with those reported in the available literature, and indicated that the investigated sods have a typical combustion profile and pattern. They were similar to typical emission combustion sources such as traffic, clinical waste incinerators, and combustion of materials containing polychlorinated biphenyls (Pcbs) Such as electrical wires and illegal scrap materials	Madrid, Spain	Clinical Waste Incinerator	N/A	Cross Sectional	Soil: n=14	Soil	400m-3000m from the incinerator	None specified	Soil: n=2	Soil	4.5kms away from the incinerator	No

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	**Media**	**Citation**	**Study Duration**	**Chemicals/ Outcome Assessed**	**Samples Collected In**	**Sample Storage Method**	**Analysis Method**	**Type of Statistical Analysis Performed**	**Sample Size**	**Correlation of Chemical Levels to Incinerator**	**Key Conclusions**	**Funding Source**	**Study Design**	**Study/Control Group Selection**	**Sample Collection**	**Critical Results Analysis**	**Include?**
57	Fauna	Eitzer, B. D. 1995 Chemosphere Polychlorinated dibenzo-p-dioxins and dibenzofurans in raw milk samples from farms located near a new resource recovery incinerator	2 years	PCDD/F concentrations	solvent rinsed brown glass jars	Samples were frozen and stored at -4 ^{0}C	HRGC/HRMS	T-Test	Bovine Milk (pre-operation): 17 Bovine Milk (post-operation): 12	Incinerator had no significant impact on the PCDD/F levels in Bovine milk samples	No significant differences were observed between the PCDD/F concentrations in the pre-operational and post-operational samples	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
62	Soil	Feng, Y. and Barratt, R. 1999 J.Environ.Monit. Distributions of lead and cadmium in dust in the vicinity of a sewage sludge incinerator	Unsure	Pb and Cd	Samples were collected be brushing (using a new brush with synthetic bristles)	Samples were stored in self-sealing plastic bags	differential pulse anodic stripping voltammetry	Statistical tests not stated.	Surface Dust: 23	Incinerator has relatively small impact on surface dust	The study found little evidence for a major contribution to local pollution by the incinerator. The highest Cd level was found about 2.2 km downwind of the prevailing wind direction from the incinerator, suggesting some resultant contamination, although the levels do not appear to be excessive. Levels of Pb do not appear to be directly attributable to the incinerator. Overall the environmental impact of the incinerator is relatively small compared with that of other human activities in the area.	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
63	Soil; Vegetation	Ferre-Huguet, N., Nadal, M., Mari, M., Schuhmacher, M., Borrajo, M. A., and Domingo, J. L. 2007 Bull.Environ.Contam Toxicol. Monitoring metals near a hazardous waste incinerator. Temporal trend in soils and herbage	2 years Soil: April 2004 Herbage: April 2005	As, Be, Cd, Cr, Hg, Mn, Ni, Pb, Sn, Tl, V	Soil: bulk samples (collection method not described) Herbage: samples were collected 5cm from the soil and immediately packed in aluminum foil	Soil: samples were dried at room temperature and sieved through a 2mm mesh screen Herbage: stored in a double aluminum fold and dried at room temperature until analysis	metal concentrations were measured by inductively coupled plasma spectrometry, or atomic-absorption spectrophotometry with graphite-furnace atomization	ANOVA, Kruskal-Wallis test	Soil: n=40 Herbage: n=40	No significant correlation between levels of heavy metals and the HWI. In some cases levels in soil and herbage actually decreased. As and Ni were significantly higher (p<0.05) in areas located away from the HWI(>4000m). In soil levels of As, Be, Mn concentrations were significantly higher in areas closer to the HWI (between 500m	Data indicate that the HWI does not result in a significant source of metal pollution in the area. The surveillance program has determined that the levels of most elements (with the potential exemption of As) do not add relevant health risks for the population living in the vicinity of the facility	Agencia de Residus, Generalitat de Catalunya, Barcelona, Spain	Moderate	Moderate	Moderate	Moderate	Yes
80	Soil	Jimenez, B., Eljarrat, E., Hernandez, L. M., Rivera, J., and Gonzalez, M. J. 1996 Chemosphere Polychlorinated dibenzo-p-dioxins and dibenzofurans in soils near a clinical waste incinerator in Madrid, Spain. Chemometric comparison with other pollution sources and soils	1 month	PCDD/F concentrations	Soil	Not elaborated.	HRGC/HRMS	Principal Component Analysis, multivariate analysis	Soil: 16	Levels of contamination are from the CWI and other emission sources	PCDD/Fs found in the investigated surface soils indicated a slight contamination be these pollutants in the studied area. The analytical PCDD/F data and the distribution of homologue PCDD/F families and the 2,3,7,8, substituted congeners do not clarify whether the CWI plant is the only source responsible for PCDD/F levels found in the analyzed soils.	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
82	Vegetation	Keller, T., Matyssek, R., and Gunthardt-Goerg, M. S. 1994 Environmental Pollution Beech foliage as a bioindicator of pollution near a waste incinerator	Since 1971 unshaded leaves from the top of marked beech trees (Fagus sylvatica l.) In the vicinity of a regional waste incinerator have been sampled every year in early september. The unwashed leaf samples were analyzed for the concentration of cl- and, in some years, for 16 other elements. The operation of the waste incinerator distinctly increased the cl- concentration in the foliage. When the flue gas filtration did not work properly, several other elements also accumulated (Without any obvious dust accumulation). There were no significant correlations between precipitation and concentration of water-soluble elements in foliage samples. This suggested that precipitation was not accelerating foliar leaching so that the bioindication of pollutant accumulation is not restricted in foliage with a well developed cuticula	Switzerland	Municipal Waste	1974	Longitudinal	Beech Foliage: unknown amount of samples per year	Foliage collected from the canopy of Beech trees	50 - 200 meters from the MWI	None Specified	Beech Foliage: unknown amount of samples per year before incinerator start-up	Foliage collected from the canopy of Beech trees	50 - 200 meters from the MWI	None Specified
91	Surface Microlayers	Knulst, J. and Sodergren, A. 1994 Chemosphere Occurrence and toxicity of persistent pollutants in surface microlayers near an incineration plant	Surface microlayers exposed to smoke plumes from an incineration plant were collected and their toxicity and content of anthropogenic compounds determined. The enriched levels of Al, Mn, Cu and Zn indicated an anthropogenic exposure, which was confirmed by increased levels of AOX and the presence of PCBs in the microlayers. AOX was enriched about twice the level found in the subsurface water (55 mug Cl L⁻¹), which pointed to an airborne, local source. The mortality of the brine shrimp Artemia spp. changed in a dose-response manner after exposure to the microlayer. The crustacean Nitocra spinipes was not affected by the microlayer and no response was shown when the Microtox method was used	Nyborg, Denmark	Industrial Waste	Not specified	Cross Sectional	Surface Microlayers: n=2	Sea-surface Microlayers	Sea-surface Microlayers were collected in areas exposed to the incinerator plume	None specified	Surface Microlayers: n=1	Sea-surface Microlayer	45kms north of the plume exposed area	None Specified
92	Ambient Air	Koblantz, S. M., Teiger, D. G., Kitto, M. E., Dutkiewicz, V. A., Matuszek, J. M., and Husain, L. 1997 Environmental Monitoring and Assessment Impact assessment of emissions from a municipal waste incinerator	Emissions from a refuse-derived fuel steam generating plant in downtown Albany, NY, have been a subject of public concern during, and since cessation of, operation of the plant. Aerosol samples routinely collected every sixth day at four air quality monitoring sites (three PM₁₀ and one TSP) in the environs of the plant were analyzed for fourteen trace metals and three combustion-related inorganic anions to detect contributions of the incinerator to the ambient burden in Albany. Statistical and correlative comparisons of the analyte concentrations were made using direct comparison of monthly, quarterly and annual arithmetic and geometric means, enrichment-factor analysis, factor analysis and correlation with wind direction, precipitation and tonnage of refuse burned. These several comparisons reveal that trace-metal and anion concentrations in the fallout of emissions from the plant are extremely low and are indistinguishable from the corresponding ambient concentrations at Albany. Factor analyses and wind-direction correlations indicate that contaminants at Albany were components of mixed air masses with	Albany, New York, USA	Municipal Waste	1981	Longitudinal, retrospective	Ambient Air from 1993 (MWI in operation): unknown (continuous sampling at 4 sampling sites)	Ambient Air	Samples were collected at 4 sites from 0.4kms to 3kms from the Incinerator	None specified	Ambient Air from 1994 (MWI not in operation): unknown (continuou s sampling at 4 sampling	Ambient Air	Samples were collected at 4 sites from 0.4kms to 3kms from the Incinerator	Not specified
100	Fauna	Liem, A. K. D., Hoogerbrugge, R., Kootstra, P. R., van, der, V, and De Jong, A. P. J. M. 1991 Chemosphere Occurrence of dioxins in cow's milk in the vicinity of municipal waste incinerators and a metal reclamation plant in the Netherlands	Over 200 samples of cow's milk have been analysed for dioxins in a survey on the occurrence of dioxins in milk from the vicinity of municipal waste incinerators (MSWs) and other potential dioxin sources in The Netherlands. Levels in milk were found to vary considerably with time, depending on emission rates, the direction and distance to the source and the feeding and housing of cows. Highest levels of up to 13.5pg TEQ/g of milk fat were found in the Lickebaert area and Zaandam near two incinerators with highest emission rates. The background level ranged between 0.7 and 2.5pg TEQ/g of milk fat. Levels in winter were comparable to those found in summer and, in some areas, even higher, when cows were fed with hay and silage harvested on the same farm. After the closure of the MSW in Zaandam, cow's milk from neighbouring farms showed a significant decrease in dioxin levels to below the critical limit of 6pg TEQ/g of milk fat. Dioxin levels in the vicinity of a metal reclamation plant were comparable to those in milk from the vicinity of a MSW with moderate emissions. Differences were observed in the ratio PCDF/PCDD, which was higher in milk near the metal reclamation plant. Principal component analysis has been applied on a large data set of patterns of the 2,3,7,8-chlorine substituted PCDDs and PCDFs in cow's milk. This	The Netherlands	Multiple Municipal Waste Incinerators	N/A	Longitudinal, Prospective	Cows Milk: >200 samples	Cows Milk	Samples were usually chosen in the area of 5x5km^2 NE from the suspected source.	None specified	Not particularly specified.	Cows Milk	Unsure	Not specified
104	Vegetation	Loppi, S., Putorti, E., Pirintsos, S. A., and De, Dominicis, V 2000 Environmental Monitoring and Assessment Accumulation of heavy metals in epiphytic lichens near a municipal solid waste incinerator (central Italy)	The epiphytic lichen Parmelia caperata was used as biomonitor in the area of a municipal solid waste incinerator (Poggibonsi, central Italy) to investigate the levels and the spatial distribution of the heavy metals Al, Cd, Cr, Cu, Fe, Hg, Pb and Zn. Levels of Al, Cu and Hg were similar to those in unpolluted areas, whereas high values were found for Cr, Zn and especially Cd. The distribution pattern of the last three metals and the exponential relationship of their concentrations with distance from the incinerator, showed that the disposal plant is a local source of atmospheric pollution due to Cd, Cr and Zn. For these metals, long-term hazard should be seriously taken into account	Poggibonsi, Italy	Municipal Waste	1996	Cross sectional, retrospective	Lichen samples: n=45 (5x9 sites)	5 thalli of the foliose lichen Parmelia caperata at each sampling site	9 sampling sites located 50m - 1100 m from the incinerator.	None specified	Lichen samples: n=10 (5x2 sites)	5 thalli of the foliose lichen *Parmelia caperata* at each sampling site	3.5 and 10 kms from the incinerator, far from any local source of air pollution	No

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	**Media**	**Citation**	**Study Duration**	**Chemicals/ Outcome Assessed**	**Samples Collected In**	**Sample Storage Method**	**Analysis Method**	**Type of Statistical Analysis Performed**	**Sample Size**	**Correlation of Chemical Levels to Incinerator**	**Key Conclusions**	**Funding Source**	**Study Design**	**Study/Control Group Selection**	**Sample Collection**	**Critical Results Analysis**	**Include?**
82	Vegetation	Keller, T., Matyssek, R., and Gunthardt-Goerg, M. S. 1994 Environmental Pollution Beech foliage as a bioindicator of pollution near a waste incinerator	20 years	Cl, Al, Ca, Cd, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, P, Pb, S, V, Zn	Not specified	Unwashed leaves were dried at 65 ^{0}C and ground	1971-1983: colometric titration with mercury nitrate 1984-1985: HPLC 1985-1991: ICP-AA	Spearman rank correlation test, Wilcoxon *u*-test	Beech Leaves: unsure amount of sampled per year	Yes, the incinerator was shown to have elevated concentration levels	The operation of the waste incinerator distinctly increased the cl- concentration in the foliage. When the flue gas filtration did not work properly, several other elements also accumulated (Without any obvious dust accumulation). There were no significant correlations between	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
91	Surface Microlayers	Knulst, J. and Sodergren, A. 1994 Chemosphere Occurrence and toxicity of persistent pollutants in surface microlayers near an incineration plant	1 month	trace metals, POPs, organic halogenated matter	Surface microlayers were collected with a remote surface "skimmer", fitted with a hydrophilic teflon film on a stainless steel drum	precleaned Pyrex glass bottles with Teflon caps, kept at 4 C in the dark	Trace Metal analysis: plasma emission mass spectrometry (ICP-MS) or plasma emission spectrometry (ICP-AES) POPs: determined accurding to Larsson and Södergren. Organic	Basic statistical analysis (mean, s.d)	Sea-surface microlayers: 2 Sea-surface microlayers (control): 1	No, the relationship between the emissions and the load in the surface film is still to be proven	Enriched levels of Al, Mn, Cu and Zn indicate an anthropogenic exposure which is confirmed by the increased levels of AOX and the presence of PCBs in the microlayer. Incinerator could not be determined as a point source because No data of the occurrence and fate of emitted organic compounds from the incineration plant exist to be compared to the levels of contamination in the sea surface sediment.	Greenpeace, Brussels and Crafoord Foundation	Moderate	Moderate	Moderate	Moderate	Yes
92	Ambient Air	Koblantz, S. M., Teiger, D. G., Kitto, M. E., Dutkiewicz, V. A., Matuszek, J. M., and Husain, L. 1997 Environmental Monitoring and Assessment Impact assessment of emissions from a municipal waste incinerator	2 years	Trace metals (Ba, Cu, Fe, Mn, V, Zn, Ca, Cr, Hg, As, Be, Cd, Ni, Pb) and anion (SO4, NO3, Cl) concentrations	High volume air samplers (quartz and glass fiber filters)	Not elaborated.	Ba, Cu, Fe, Mn, V, Zn, Ca: inductivly coupled plasma emission spectrometry (ICP) Total Cr: Atomis absorption	statisitcal and correlative comparisons (acutal tests not named)	Ambient Air: sample size not stated	Any impact from the incinerator was not apparent at any sampling site	several comparisons reveal that trace-metal and anion concentrations in the fallout of emissions from the plant are extremely low and are indistinguishable from the corresponding ambient concentrations at Albany. Factor analyses and wind-direction correlations indicate that contaminants at Albany	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
100	Fauna	Liem, A. K. D., Hoogerbrugge, R., Kootstra, P. R., van, der, V, and De Jong, A. P. J. M. 1991 Chemosphere Occurrence of dioxins in cow's milk in the vicinity of municipal waste incinerators and a metal reclamation plant in the Netherlands	2 years	PCDD/F concentrations	Samples collected in new glass bottles	Samples were stored at -20 ^{0}C	GC/MS	Principal Component Analysis	Cows Milk: >200 samples	Increased dioxin levels may occur in cows milk in the vicinity of MWI and metal reclamation plants.	Increased dioxin levels may occur in cows milk in the vicinity of MWI and metal reclamation plants. Levels were significantly above the Dutch background level of 0.7-2.5 pg TEQ/g of fat. The use of contaminated hay and ensilage may be the cause of high dioxin levels in the winter season.	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
104	Vegetation	Loppi, S., Putorti, E., Pirintsos, S. A., and De, Dominicis, V 2000 Environmental Monitoring and Assessment Accumulation of heavy metals in epiphytic lichens near a municipal solid waste incinerator (central Italy)	1 year	Heavy metals (Al, Cd, Cr, Cu, Hg, Mn, Fe, Pb, Zn)	Not specified	lichen sampled were air dried and sorted to remove dead or senescent tissue and as much extraneous material as possible	atomic absorption spectroscopy, graphite furnace, cold vapour technique	non-linear exponential regression	Lichen: 45 Lichen (control): 10	Cd, Cr, Zn contamination conclusively correlated to incinerator,	The distribution pattern of some heavy metals and their exponential relationship with distance from the incinerator, showed that the combustion facility of a local source of atmospheric pollution due to Cd, Cr, and Zn.	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
105	Ambient Air; Soil	Lorber, M., Pinsky, P., Gehring, P., Braverman, C., Winters, D., and Sovocool, W. 1998 Chemosphere Relationships between dioxins in soil, air, ash, and emissions from a municipal solid waste incinerator emitting large amounts of dioxins	The Columbus Municipal Waste-to-Energy (Columbus WTE) facility in Columbus, Ohio, began operation in June, 1983 and ceased operation in December, 1994. During its operation, it was estimated to have released nearly 1,000 grams of dioxin Toxic Equivalents (TEQs) per year. This compares to a 1994 estimate of 9,300 g TEQ/yr from all sources emitting dioxins into the air in the United States (EPA, 1994), and to total releases of dioxins near or below 1,000 grams TEQ/Yr for England (Eduljee and Keyke, 1996), Belgium (Wevers and De Fre, 1995), and West Germany (Fiedler and Hutzinger, 1992). Because of the magnitude of emissions from this single source, studies were undertaken to evaluate the impacts to air and soil near the incinerator. This paper presents analyses evaluating dioxin concentrations and profiles in four media: stack gas, ambient air within 3 km of the incinerator, soil samples up to 8 km from the incinerator, and incinerator ash. Principal findings include: 1) an "incinerator signature" profile, as defined by stack gas emissions, was found in the ash and in subsets of the air and soil matrices, 2) soil concentrations declined from directly outside the incinerator property to the city at large, 3) an urban background soil concentration of dioxin Toxic Equivalents (TEQs) was estimated at 4 pg/g, while concentrations generally within 2 km of the incinerator ranged from 4-60 pg TEQ/g, 4) an urban background air concentration was estimated at 0.05 pg TEQ/m3, while air concentrations at a specific location about 2 km in the downwind direction of the incinerator had concentrations of 0.17 and 0.35 pg	Columbus, Ohio	Municipal Waste	1983	Longitudinal, Prospective	Ambient Air: n=16 Soil: n=35	Ambient Air and Soil Samples	Ambient Air: sampled in 1994 and 1995 and taken at 1.8 to 3.90 kms from the MWI Soil: sampled in 1995 and 1996, 4 samples taken from the incinerator property, and 31 samples taken from	None specified	Ambient Air: n=3 (2 in 1994, and 1 in 1995) Soil: n=3	Ambient Air and Soil Samples	Ambient Air: taken from am area 45kms away Soil: sampled in 1995 at the same area as the background ambient air 45kms away from the incinerator	No
106	Fauna	Lovett, A. A., Foxall, C. D., Creaser, C. S., and Chewe, D. 1998 Chemosphere PCB and PCDD/DF concentrations in egg and poultry meat samples from known urban and rural locations in Wales and England	A survey was undertaken of PCB and PCDD/DF congeners in eggs and poultry meat from a smallholding close to a chemical waste incinerator, other sites in the surrounding district, and three rural locations. The concentrations from the site close to the incinerator were appreciably greater than those found elsewhere, although the contrast was less marked for poultry meat than eggs. All types of poultry produce displayed noticeable variations in congener composition when the samples were grouped according to geographical origin. These results support the view that the environment in which poultry live does influence the PCB and PCDD/DF characteristics of their products. Exposure calculations indicated that consumption of eggs from the site close to the incinerator would constitute a substantial proportion of recommended daily intakes for such contaminants and at the present time these products are not being eaten	Panteg, UK	Hazardous Waste	1972	Cross sectional	Eggs: n=not specified Duck Meat: n=not specified	Eggs (chicken, bantam, and duck) and Duck meat	Samples were collected from 4 smallholdings in the Panteg district (near the HWI)	None specified	Eggs: n=not specified Duck Meat: n=not specified	Eggs (chicken, bantam and duck) and duck meat	Control samples were from 8 smallholdings in 3 rural areas.	No
107	Vegetation	Lovett, A. A., Foxall, C. D., Creaser, C. S., and Chewe, D. 1997 Chemosphere PCB and PCDD/DF congeners in locally grown fruit and vegetable samples in Wales and England	A survey was undertaken of PCB and PCDD/DF congeners in fruit and vegetables grown in an urban areas close to a chemical waste incinerator and three rural locations. All of the concentrations detected were low and there was considerable overlap between those found in urban and rural samples. Some similarities with the congener composition of air samples were identified and concentrations in apple skin were noticeably higher than those in the flesh of the fruit. These results suggest that atmospheric deposition was an important contamination pathway. Assessments using the highest concentrations found indicated that consumption of such fruit and vegetables would represent an additional 3% of the normal dietary intake for PCBs and 8% for PCDD/DFs	Panteg, UK	Hazardous Waste	1972	Cross sectional	Vegetables: not stated	Apples, Courgette, Lettuce and Potato	Sampling sited were all within a radius of 1.5km of the HWI	None specified	Vegetables : not specified	Apples, Courgettes, Lettuce and Potato	Control sampled were collected in areas devoted to arable farming or fruit and vegetable production.	No
115	Ambient Air	Mari, M., Nadal, M., Schuhmacher, M., and Domingo, J. L. 7-24-2008 Chemosphere Monitoring PCDD/Fs, PCBs and metals in the ambient air of an industrial area of Catalonia, Spain	In 2005 and 2006, the levels of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), polychlorinated biphenyls (PCBs) and metals (As, Be, Cd, Co, Cr, Cu, Mn, Ni, Pb, Sn, Tl and V) were measured in air samples collected in an industrial area of Sant Adria del Besos (Barcelona, Catalonia, Spain) where a municipal solid waste incinerator (MSWI) is placed, and in a background/control area. In general terms, concentrations of all environmental pollutants were higher at the industrial site. No significant seasonal/temporal variations were observed in any of the areas. No Pearson correlation was found between the PCDD/F concentrations and the environmental conditions of the two sampling periods considered. Principal component analyses (PCA) were performed to get information on the relationship among samples, pollutants, and emission sources. The results indicate that the MSWI of S. Adria de Besos is not a significant emission source of the above compounds for the area under its direct influence. Moreover, a notable difference in the PCDD/F congener profiles was found between ambient air and stack gas emissions, indicating that the current levels of PCDD/Fs are more related to other potential emissions sources rather than to those from the MSWI	Catalonia, Spain	Municipal Waste	Not specified	Longitudinal, Prospective	Not particularly specified	Ambient Air samples	2 sites located at 500m from the incinerator 1 site located at 1 km from the incinerator	None Specified	Not particularly specified.	Ambient air samples	suburban area located near a green space of Barcelona with no direct industrial pollutant sources	No

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
105	Ambient Air; Soil	Lorber, M., Pinsky, P., Gehring, P., Braverman, C., Winters, D., and Sovocool, W. 1998 Chemosphere Relationships between dioxins in soil, air, ash, and emissions from a municipal solid waste incinerator emitting large amounts of dioxins	2 years	PCDD/F	Ambient Air: PS-1 air sampler Soil: stainless steel tulip bulb planting device	Not elaborated.	Not stated	Principal Component Analysis	Ambient air: 19 Soil: 38	Yes, profiles of ambient air and soil are similar to the stack gas profiles.	An "incinerator signature" profile , as defined by stack gas emissions was found in the ask and in subsets of the air and soil matrices. Soil concentrations declined from directly outside the incinerator property to the city at large. An urban background soil concentration of dioxin Toxic Equivalents (TEQs) was estimated at 4 pg/g, while concentrations generally within 2 km of the incinerator ranged from 4-60 pg TEQ/g.	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
106	Fauna	Lovett, A. A., Foxall, C. D., Creaser, C. S., and Chewe, D. 1998 Chemosphere PCB and PCDD/DF concentrations in egg and poultry meat samples from known urban and rural locations in Wales and England	6 months	PCBs, PCDD/F concentrations	Not elaborated.	Not elaborated.	Not stated	None stated	Not specified	Yes, high PCB content in eggs closest to incinerator	Results confirm that PCB and PCDD/F levels in egg samples collected from Pontyfelin House were substantially higher than those found elsewhere in the Panteg district or at rural locations. The results support the view that the environment in which poultry live does influence the PCB and PCDD/F characteristics of their products.	Welsh Office, UK	Moderate	Moderate	Moderate	Moderate	Yes
107	Vegetation	Lovett, A. A., Foxall, C. D., Creaser, C. S., and Chewe, D. 1997 Chemosphere PCB and PCDD/DF congeners in locally grown fruit and vegetable samples in Wales and England	2 days	PCBs, PCDD/F concentrations	Not elaborated.	Not elaborated.	Not stated	Mann-Whitney U-test	Not specified	No conclusive correlation to HWI (considerable concentration overlap between sample and control)	No statistically significant differences in concentrations between produce grown locally and in the residential areas of Panteg and that from rural sites were found. Any potentially increased intake of PCBs and PCDD/Fs resulting from the ingestion of apples lettuce and potatoes was considered unlikely to exceed 3% and 8% of the respective average daily intakes of these contaminants from all food sources.	Welsh Office, UK	Moderate	Moderate	Moderate	Moderate	Yes
115	Ambient Air	Mari, M., Nadal, M., Schuhmacher, M., and Domingo, J. L. 7-24-2008 Chemosphere Monitoring PCDD/Fs, PCBs and metals in the ambient air of an industrial area of Catalonia, Spain	Not specified	PCDD/F, PCBs, As, Be, Cd, Co, Cr, Cu, Mn, Ni, Pb, Sn, Tl, V	high volume air samplers; TE-6070DV Air sampler	Not elaborated.	HRGC/HRMS	Levene Test; ANOVA test	Not stated	Non-significant levels of chemical agents were correlated to the MWI	The MWI is not a strong emission source of PCDD/Fs, PCBs, and heavy metals and does not contribute significantly to the air pollution in its immediate surrounding. No significant temporal, seasonal, or spatial variations have been observed. The PCDD/F congener profiles has been found between ambient air and emission gas; indicating that the current levels of PCDD/Fs are more related to other potential sources rather than to	Metropolitan Entity of the Environment, Barcelona, Catalonia, Spain	Moderate	Moderate	Moderate	Moderate	Yes

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
120	Vegetation	Misik, M., Micieta, K., Solenska, M., Misikova, K., Pisarcikova, H., and Knasmuller, S. 2007 Environ.Pollut. In situ biomonitoring of the genotoxic effects of mixed industrial emissions using the Tradescantia micronucleus and pollen abortion tests with wild life plants: demonstration of the efficacy of emission controls in an eastern European city	Aim of the study was to monitor changes of genotoxic activity of urban air caused by an incinerator and a petrochemical plant in Tradescantia micronucleus (Trad-MCN) and pollen fertility assays with wild plants (Chelidonium majus, Clematis vitalba, Cichorium intybus, Linaria vulgaris, Robinia pseudoacacia). While in the first sampling period (1997-2000) significantly (on average 80%) more MN were found at the polluted site in comparison to controls from a rural area, no significant effects were observed during a later period (between 2003 and 2005). A similar pattern was observed in the pollen abortion assays in which the most pronounced effects were found in chicory and false acacia. The differences of the results obtained in the two periods can be explained by a substantial reduction of air pollution by use of new technologies. In particular the decrease of SO(2) emissions may account for the effects seen in the present study	Bratislava, Slovak Republic	Municipal Waste	N/A	Longitudinal, Prospective	Wild plant Species: n=5/year n(total)=35	Wild plant species (chicory, old mans beard, common toadflax, greater celandine, flase acacia)	approx 150m from the MWI and approx 200m from a petrochemical plant	None Specified	wild plants: n=5/year n(total)=35	Wild plant species (chicory, old mans beard, common toadflax, greater celandine, flase acacia)	Control samples collected from a rural area with low pollution levels in Western Slovakia at the same time a study group samples	N/A
125	Ambient Air	Mukerjee, S., Somerville, M. C., Willis, R. D., Fox, D. L., Stevens, R. K., Kellogg, R. B., Stiles, D. C., Lumpkin, T. A., and Shy, C. M. 1996 Environmental Science and Technology Integrated assessment of reduced emission impacts from a biomedical waste incinerator. Atmospheric characterization and modeling applications on particulate matter and acid gases	A composite approach involving wind sector analyses, receptor modeling, and dispersion modeling has been developed to estimate the impact of a biomedical waste incinerator (BWI). This is presented using measurements of 12-h ambient air particulate matter and acid gases from a versatile air pollutant sampler, with meteorological data obtained near the BWI as part of a larger short-term respiratory effects study. Monitoring was performed in the same time frame for three consecutive years, the first year being prior to installation of air pollution control devices (APCDs) at the BWI, the next year with the BWI having APCDs, and the final year with the BWI being 'moth-balled'. Use of integrated wind sector analyses and receptor/dispersion modeling provided evidence of reduced emission impacts at the monitoring site during the 3-year period. Principal component analysis combined with linear-angular correlation and regression provided further evidence of reduced BWI impacts in addition to information about the nature of emission sources. The effectiveness of applying a wind direction-based receptor/dispersion model approach to assess emission abatement plans is demonstrated	North Carolina	Biological Waste	N/A	Longitudinal, Prospective	Ambient air: not specified	Ambient Air	approx 850 meters southeast of the monitoring site	None Specified	Ambient Air: Not specified	Ambient Air	2 miles from the BWI	N/A
129	Soil; Vegetation	Nadal, M., Bocio, A., Schuhmacher, M., and Domingo, J. L. 2005 Arch.Environ.Contam Toxicol. Trends in the levels of metals in soils and vegetation samples collected near a hazardous waste incinerator	In 1998 and 2001, the levels of a number of elements (As, Be, Cd, Cr, Hg, Mn, Ni, Pb, Sn, Tl, and V) were determined in 40 soil and 40 herbage samples collected near a new hazardous waste incinerator (HWI) (Constanti, Catalonia, Spain). In 2003, soil and herbage samples were again collected at the same sampling points in which samples had been taken in the previous surveys. During the period 1998-2003, As, Be, Cr, Ni, and V levels showed significant increases in soils. In contrast, the levels of Cd, Hg, and Sn significantly decreased. With respect to herbage, while Cr, Mn, and V concentrations significantly increased, those of As levels diminished. On the other hand, human health risks derived from metal ingestion and inhalation of soils were also assessed. In relation to noncarcinogenic risks, all elements presented a value inside the safe interval. In turn, Cd and Cr were also in the safe interval of carcinogenic risks, whereas in contrast As levels clearly exceeded the regulatory limits concerning carcinogenic risks. According to the results of the previous (2001) and current (2003) surveys, the fluctuations in the metal concentrations suggest that the influence of the HWI is minimal in relation to other metal pollution sources in the area	Constanti, Catalonia, Spain	Hazardous Waste	1999	Longitudinal, Prospective	Soil: n=40 Herbage: n=40 (30 rural areas, 10 urban areas)	Soil: topsoil bulk samples representing an area of approx 1m^2 at each sampling site. Herbage: *pipatherum paradoxum* were collected 5cm from	samples were collected within 8km from the HWI	None Specified	See Ref ID 35 for baseline data	N/A	N/A	N/A
132	Ambient Air; Soil	Oh, J. E., Choi, S. D., Lee, S. J., and Chang, Y. S. 2006 Chemosphere Influence of a municipal solid waste incinerator on ambient air and soil PCDD/Fs levels	To examine the influence of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/Fs) emissions from a municipal solid waste incinerator (MSWI) on the environment, we measured the levels of PCDD/Fs in ambient air and soil samples collected near a MSWI in Bucheon, Korea. The PCDD/Fs concentrations in the ambient air samples ranged from 0.22 to 1.16 pg I-TEQm(-3) (13.39-75.16 pg m(-3)), with an average of 0.66 pg I-TEQ m(-3) (35.62 pg m(-3)). The soil samples contained between 1.25 and 74.98 pg I-TEQ g(-1) (38.15-3,303.33 pg g(-1)), with an average of 19.06 pg I-TEQ g(-1) (1,077.11 pg g(-1)). These levels were higher than those previously reported by other investigators in a number of surveys. The furan homologues predominated in the air samples and some soil samples, and the soil PCDD/Fs levels decreased with increasing distance from the MSWI. Comparison of the homologue patterns and a multivariate statistical analysis showed that PCDD/Fs emission from the MSWI directly affected the pattern of PCDD/Fs in air, while the PCDD/Fs patterns in soil differed according to the location relative to the MSWI, roads, and construction sites. These results collectively indicate that the MSWI was the major PCDD/Fs emission source in this area, but that unidentified combustion sources and vehicles might influence the environment to some extent	Bucheon City, Korea	Municipal Waste	1995	Longitudinal, Prospective	Ambient Air: n=10 Soil: n=10	Ambient Air and Soil Samples	Ambient Air: sampled at 3 sites within 1 km from the MWI Soil: 9 samples were collected within 1 km of the MWI, and 1 sample was collected at 2kms from the MWI	None Specified	Soil: n=1	Soil Sample	Mt. Dobong, a national park located 30kms away from the MWI	No

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
120	Vegetation	Misik, M., Micieta, K., Solenska, M., Misikova, K., Pisarcikova, H., and Knasmuller, S. 2007 Environ.Pollut. In situ biomonitoring of the genotoxic effects of mixed industrial emissions using the Tradescantia micronucleus and pollen abortion tests with wild life plants: demonstration of the efficacy of emission controls in an eastern European city	7 years	measurement of genotoxic effects (pollen grain abortion)	Not specified	Not elaborated.	abortive grains were evaluated under a light microscope	Wilcoxons signed rank test	Wild plants: 35 Wild plants (control): 35	No, the genotoxic effects could be attributed to either the emission from the MWI or the petrochemical plant or a combination of both (likely the case)	In the first sampling period (1997-2000) significantly more abortive pollen grains were seen in the study group in comparison to the control group, whereas no significant effects were found in the second sampling period (2003-2005). This is explained by the implementation of an effective air filtration system in the MWI, and by use of new production techniques in the petrochemical plant. The results show that pollen abortion tests can be used to	Slovak grant agency	Moderate	Moderate	Moderate	Moderate	Yes
125	Ambient Air	Mukerjee, S., Somerville, M. C., Willis, R. D., Fox, D. L., Stevens, R. K., Kellogg, R. B., Stiles, D. C., Lumpkin, T. A., and Shy, C. M. 1996 Environmental Science and Technology Integrated assessment of reduced emission impacts from a biomedical waste incinerator. Atmospheric characterization and modeling applications on particulate matter and acid gases	3 years	fine fraction particulate, acid gas, trace metals	Versatile Air Pollution Sampler	Not elaborated.	Not stated	Principal Component Analysis	Ambient Air: not specified Background ambient air: not specified	PCA indicated that the BWI contributed to emissions in 1992 but a contribution from the BWI in 1993 and 1994 could not be seen	The reduction of BWI emissions are correlated to the installation of air pollution control devices.	USEPA	Moderate	Moderate	Moderate	Moderate	Yes
129	Soil; Vegetation	Nadal, M., Bocio, A., Schuhmacher, M., and Domingo, J. L. 2005 Arch.Environ.Contam Toxicol. Trends in the levels of metals in soils and vegetation samples collected near a hazardous waste incinerator	1 year	As, Be, Cd, Cr, Hg, Mn, Ni, Pb, Sn, Tl, V	Soil: bulk samples (collection method not described) Herbage: samples were collected 5cm from the soil and immediately packed in aluminum foil	Soil: samples were dried at room temperature and sieved through a 2mm mesh screen Herbage: stored in a double aluminum fold and dried at room temperature until analysis	metal concentrations were measured by inductively coupled plasma spectrometry, or atomic-absorption spectrophotometry with graphite-furnace atomization	ANOVA, Kruskal-Wallis test	Soil: n=40 Herbage: n=40	fluctuations in the metal concentrations suggest that the influence of the HWI is minimal in relation to other metal pollution sources in the area	As, Be, Cr, Ni, and V levels showed significant increases in soils. Levels of Cd, Hg, and Sn significantly decreased. With respect to herbage, while Cr, Mn, and V concentrations significantly increased, those of As levels decreased. Human health risks: noncarcinogenic risks, all elements presented a value inside the safe interval. Cd and Cr were also in the safe interval of carcinogenic risks, whereas in contrast As levels exceeded the regulatory limits	Agencia de Residus, Generalitat de Catalunya, Barcelona, Spain	Moderate	Moderate	Moderate	Moderate	Yes
132	Ambient Air; Soil	Oh, J. E., Choi, S. D., Lee, S. J., and Chang, Y. S. 2006 Chemosphere Influence of a municipal solid waste incinerator on ambient air and soil PCDD/Fs levels	15 months	PCDD/F concentrations	Not elaborated.	Not elaborated.	HRGC/HRMS	Cluster Analysis, Principal Component Analysis	Ambient Air: 10 Soil: 10 Soil (control): 1	MWI was the major PCDD/F emission source in this area but that unidentified combustion sources and vehicles might influence the environment to some extent.	PCDD/F levels in both air and soil were higher than those reported by other investigators with soil PCDD/F levels decreasing with increasing distance to the MWI. MWI was the major PCDD/F emission source in this area but that unidentified combustion sources and vehicles might influence the environment to some extent. PCDD/F emission from the MWI more directly affected the pattern of PCDD/Fs in air, while the soil samples could be	Korea Science and Engineering Foundation	Moderate	Moderate	Moderate	Moderate	Yes

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
134	Soil	Ohsaki, Y., Matsueda, T., and Ohno, K. 1995 Water Research Levels and source of non-ortho coplanar polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and polychlorinated dibbenzofurans in pond sediments and paddy field soil	Non-ortho chlorine substituted coplanar polychlorinated biphenyl (Co-PCBs), polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in the sediment samples from reservoir and irrigation ponds, and in a soil from paddy field were analyzed isomer specifically using ¹³C-labeled their respective internal standards and a selected ion monitoring method of high resolution gas chromatograph mass spectrometry (GC/MS). These compounds were found in all samples analyzed. The average concentrations of the total Co-PCBs, PCDDs and PCDFs in the 10 sediment samples taken from reservoir ponds were 83, 3900 and 360 pg/g of dry weight, respectively, those in 7 sediments from irrigation ponds were 96, 3200, and 96 pg/g, those in 10 sediments from an irrigation pond near an incineration facility were 260, 10,000, and 290 pg/g, respectively, and those in the soil from a paddy field near an incineration facility were 120, 96,000, and 4700 pg/g, respectively. The concentrations of Co-PCBs, PCDDs and PCDFs in the sediments of the irrigation pond were higher than those in the sediments of any other ponds. On the other hand, the concentrations of PCDDs in the paddy field soil were much higher than those in any other sediment samples, but the Co-PCB concentration was about one-half of those in the sediments of an irrigation pond near the facility. These findings suggest that one of pollution sources of Co-PCBs as well as PCDDs and PCDFs, was municipal waste incineration, but that Co-PCB pollution was not caused by herbicides applied in the past	Fukuoka City, Japan	Municipal Waste	N/A	Cross sectional	Soil from Irrigation pond: n=10 Soil from paddy field: 1	Soil sample from an irrigation pond and paddy field	irrigation pond 600 meters away from the MWI	None Specified	Soil: n=1	Soil from an irrigation pond	10 kms away from Fukuoka City	No
137	Vegetation	Otani, T., Seike, N., and Miwa, T. 2006 Shokuhin Eiseigaku Zasshi Levels of dioxins in rice, wheat, soybean, and adzuki bean cultivated in 1999 to 2002 in Japan and estimation of their intake	A total of 369 samples of rice (n = 311), wheat (n = 10), soybean (n = 44), and adzuki bean (n = 4) collected from various locations in Japan between 1999 and 2002 were analyzed for PCDDs, PCDFs (PCDD/Fs) and coplanar PCBs. Sampling points within about 1 km of operational municipal waste incinerators that were considered sources of dioxins were defined as "near-source" areas, and all other sampling points were defined as "general" areas. The toxic equivalent quantity (TEQ) values of soybean samples collected from near-source areas were significantly higher (p < 0.05) than those from general areas. A significant difference of TEQs among sampling years in rice in general areas was also found. However, the differences could not be explained by the presence or absence of incineration plants in the area surrounding the sampling point or by a temporal decrease of air pollution. The TEQs of the crops varied widely, but the median value of each crop was quite low, at 0.000021, 0.00013, 0.0000095, and 0.00016 pg-TEQ/g wet wt. in rice, wheat, soybean and adzuki bean, respectively. On the basis of these survey results, the daily intake of PCDD/Fs and coplanar PCBs from rice, wheat, soybean, and adzuki bean was calculated. The daily intakes from these crops were estimated to be 0.0056 pg-TEQ/kg B.W./day on the assumption that "not detected" (ND) could be taken as zero, ND = 0, and 0.18 pg-TEQ/kg B.W./day if ND is put equal to 1/2 LOD (half the limit of detection). In comparison with the tolerable daily intake set in Japan for PCDD/Fs and coplanar PCBs (4 pg-TEQ/kg B.W./day), it was	Japan	Municipal Waste	N/A	Longitudinal, Prospective	Rice: n=160 Wheat: n=4 Soybean: n=19 Adzuki bean: n=2	Rice, Wheat, Soybean, Adzuki bean	All sampled were within 1km of municipal waste incinerator	None Specified	Rice: n=151 Wheat: n=6 Soybean: n=25 Adzuki bean: n=2	Rice, Wheat, Soybean, Adzuki bean	All samples were taken at least 1 km away from a municipal waste incinerator	No
141	Ambient Air; Vegetation	Poon, C., Gregory-Eaves, I., Connell, L. A., Guillore, G., Mayer, P. M., Ridal, J., and Blais, J. M. 2005 Environ.Toxicol.Chem. Air-vegetation partitioning of polychlorinated biphenyls near a point source	We investigated polychlorinated biphenyl (PCB) emissions to the environment from a waste treatment and transfer facility over the course of three years. We show that the facility, which undertakes PCB waste consolidation and maintains a low-yield incinerator for products such as light ballasts, acted as a point source for the spatial distribution of PCBs in vegetation. Concurrent air and vegetation sampling was performed to study the relationship between air-vegetation partitioning and the octanol-air partition coefficient (KOA). We show evidence of equilibrium partitioning for lower-chlorinated congeners (log KOA between 7 and 8.5), kinetically limited deposition on plants for intermediate congeners (log KOA between 8.5 and 11), and particle-bound deposition for congeners with high log KOA values (> 11), consistent with the McLachlan partitioning model. From spring to autumn, heavier congeners become much more concentrated in samples farther away from the facility, possibly because of higher temperatures, which enhance dispersal of these congeners. Multivariate principal components analysis showed that PCB composition in vegetation near the emission source most closely resembled the Aroclor mixtures processed by the treatment facility	Cornwall, Ontario, Canada	Hazardous Waste (PCB treatment facility)	N/A	Longitudinal, Prospective	Ambient Air samples: n= 5(outside facility) 4 (inside facility) Vegetation: 31	Ambient air Californian Maple Leaves	Outdoor ambient air samples were taken from 260m NE (downwind) from the facility. Indoor air samples were taken from the ballast splitting room, furnace room, and the warehouse. Vegetation	None specified	Background outdoor air samples: n=3 No control group for vegetation	ambient air samples (outdoor)	Sites B and C were location at 4.0km and 4.4kms respectively. SW from the facility.	Not specified
143	Worker Ambient Air	Rahkonen, P. 1992 Waste Manage.Res. Airborne contaminants at waste treatment plants	Airborne contaminants in finnish waste treatment plants were studied at two plants using mainly manual sorting and one incineration plant. Air samples were analysed for mesophilic and thermotolerant bacteria, mesophilic fungi, endotoxin, dust and heavy metals (Lead, cadmium). The concentrations of mesophilic bacteria in the working air of the waste treatment plants were under 2u) M-3 and the concentrations of mesophilic fungi were under 7 104 cfu m-3. There was no seasonal variation in the concentrations of bacteria, but the concentrations of fungi were highest in autumn at the waste incineration plant. The concentrations of microbes recorded with two sampling methods, the andersen and nuclepore filter methods, differed by were usually of the same order of magnitude. The identified bacteria did not include any potent pathogens. In manual sorting the level of organic dust reached 38 mg m-3, whereas the 8-h hygiene limit value for organic dust is 5 mg m-3 and the 15-mi	Finland	Municipal Waste	N/A	Cross sectional	Air Samples: Not particularly specified	Samples were taken from the workers breathing zones	Samples taken from the unloading hall, bunker hall, cabin of the crane, kiln hall, basin and central control room	None Specified	Background Air: not specified	Air Samples	Taken from an area where there was not corresponding load	Not specified

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
134	Soil	Ohsaki, Y., Matsueda, T., and Ohno, K. 1995 Water Research Levels and source of non-ortho coplanar polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins and polychlorinated dibbenzofurans in pond sediments and paddy field soil	7 months	Co-PCBs, PCDD/Fs	Samples collected with a trowel, what they were contained in is not stated	Not elaborated.	GC/MS	None stated	Soil (irrigation pond): 10 Soil (paddy field): 1	One of the Co-PCB contamination sources was accentuated to be the MWI facility as in the case of PCDD/Fs	The co-PCB concentration in the sediment decreased with an increase in the depth of the soil sampling point The MWI was considered to be one source of PCDD/F and co-PCB contamination in soil	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
137	Vegetation	Otani, T., Seike, N., and Miwa, T. 2006 Shokuhin Eiseigaku Zasshi Levels of dioxins in rice, wheat, soybean, and adzuki bean cultivated in 1999 to 2002 in Japan and estimation of their intake	2 years	PCDD/PCDF Concentrations PCB	N/A	crop samples , brown rice without chaff, threshed wheat, and seeds without pods were milled uniformly *samples were preserved in a freezer @ -20 C until extraction*	High resolution gas chromatograph equipped with a high resolution mass spectrometer	Mann-Whitney *U*-test, Kruskal Wallis test	Rice: n=311 Wheat: n=10 Soybean: n=44 Adzuki bean: n=4	Authors could not link to congener profile in the soybean conclusively to the municipal waste incinerator.	Though soybeans showed a significantly higher ($p<0.05$) TEQ in the source area than the general area the authors could not conclusively state that the TEQ levels were directly attributable to the municipal waste incinerator	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
141	Ambient Air; Vegetation	Poon, C., Gregory-Eaves, I., Connell, L. A., Guillore, G., Mayer, P. M., Ridal, J., and Blais, J. M. 2005 Environ.Toxicol.Chem. Air-vegetation partitioning of polychlorinated biphenyls near a point source	2 years	PCB concentrations	Air: Samples were collected by drawing air from the atmosphere over a glass-fiber filter Vegetation: not elaborated	Air: filters were stored in a solvent-rinsed jar Vegetation: leaves were stored in a freezer at -20 C	Gas Chromatographic analysis	Multivariate analysis, power analysis	Ambient Air: 9 Background Ambient Air: 3 Vegetation: 31	Yes PCB concentrations in air and vegetation were found to be correlated with the PCB incinerator	The decrease in total PCB concentration with distance confirms that the treatment facility was a point source for PCBs during the period from 1999-2001 Air samples collected at different areas of the treatment facility reflect large differences between indoor and outdoor PCB concentration in air but also similarities in congener profiles, suggesting that fugitive emissions were the major sources.	Natural Sciences and Engineering Research Council of Canada (NSERC)	Moderate	High	Moderate	Moderate	Yes
143	Worker Ambient Air	Rahkonen, P. 1992 Waste Manage.Res. Airborne contaminants at waste treatment plants	8 months	Microbes, Edotoxin, Dust and Heavy Metals (Pb, Cd)	Microbes: 6-stage Andersen sampler and Nuclepore filters Endotoxins: stationary sampler Dust and Heavy Metals: Millipore cellulose acetate filters	Not elaborated.	Microbes: gas liquid chromatography, API kits Endotoxins: Coatest Dust and Heavy Metals: amt of dust was determined by weighing filters, Pb and Cr were determined using atomic	power analysis	Unsure of sample sizes	Yes air particulates were assumed to be caused by incineration processes	No significant differences between waste treatment methods were found (sorting plants vs., incineration plants). Dust and microbes at the incineration plant can reach high levels during unloading and in the bunker hall. The identified bacteria did not include any potent pathogens. In manual sorting the level of organic dust reached 38 mg m-3, whereas the 8-h hygiene limit value for organic dust is 5 mg m-3 and the 15-mi hygiene limit value is 10 mg m^{-3}.The	Finnish Work Environment Fund	Moderate	Moderate	Moderate	Moderate	Yes

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
144	Fauna	Ramos, L., Eljarrat, E., Hernandez, L. M., Alonso, L., Rivera, J., and Gonzalez, M. J. 1997 Chemosphere Levels of PCDDs and PCDFs in farm cow's milk located near potential contaminant sources in Asturias (Spain). Comparison with levels found in control, rural farms and commercial pasteurized cow's milks	Cows milk samples from 12 dairy farms in Spain and 23 samples of pasteurised cows milk were analysed for PCDD/F. Farms located in rural areas without specific dioxin sources (background levels) ranged from 1.3 to 2.47 pg TEQ/g fat basis. These values were slightly lower than those found in milk from the vicinity of potential dioxin emission sources (waste incinerator, chemical and metallurgical industry) and similar to milk near paper industry. The waste incinerator seems to be the emission source with the highest influence on the cows milk gathered in its vicinity. Thus, milk near the waste incinerator exhibited the highest PCDD/F levels, the highest PCDF/PCDD ratio and its congener PCDD pattern showed the highest difference respect to its control point. The PCDD/F average concentrations found in pasteurised commercial milk were lower than those found in raw milk and were comparable to those found in retail milk from other countries	Asturias, Northern Spain	Industrial and Municipal Waste	N/A	Cross sectional	Cows milk: 1 farm (unsure how many milk samples were taken)	Cows Milk	Farm was located approx 500 meters from the Incinerator	None Specified	Cows milk: 1 farm (unsure how many milk samples were taken). 2 farms located in Central Spain (unsure of how many samples). 23	Cows Milk	Farm was located over 10kms from the Incinerator	No
151	Soil	Rimmer, D. L., Vizard, C. G., Pless-Mulloli, T., Singleton, I., Air, V. S., and Keatinge, Z. A. 3-1-2006 Sci.Total Environ. Metal contamination of urban soils in the vicinity of a municipal waste incinerator: one source among many	Concern from local residents about possible contamination with metals and PCDD/F (dioxins and furans) from fugitive and stack emissions from the Byker municipal solid waste incinerator in Newcastle upon Tyne led the City Council to initiate a study of the concentration of these pollutants in soils. We report here the results for the metals and arsenic. Soils were sampled at distances up to 2.25 km from the incinerator stack. The intensity of sampling in concentric zones was four times greater in the northeast (down-wind) direction, and twice as great in the northwest and southeast directions, compared to the southwest (up-wind) direction. In total 163 samples were collected and analyzed for total As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn. Concentrations were generally elevated above background levels, but were typical of those found in other urban areas. For As, Cd, Cu, Hg, Pb, and Zn, contamination hotspots were identified. These were spread throughout the sampling area, and there was no evidence of greater concentrations down-wind of the incinerator compared to other directions, nor of any trend in concentration at increasing distance from the incinerator. We concluded that metal contamination resulting from the incinerator could not be detected in an environment with generally elevated concentrations. Potential sources for many of the hotspots of contamination were identified in a survey of historic land use based on maps of the locality dating back to 1856. Detailed investigations of particular areas with serious contamination will now be undertaken by the local authorities using the CLEA (Contaminated Land Exposure Assessment) model	Byker MWI, Newcastle upon Tyne, United Kingdom	Municipal Waste	N/A	Cross sectional	Soil: n=163	Soil Samples	Area around MWI was divided into 4 sectors (NE, SE, SW, NW) and into distance bands of 50m up to 750m, and thereafter into bands of 250m up to 2.25kms.	None Specified	Used background concentrations for UK soils	N/A	N/A	N/A
153	Ambient Air	Roth, A. J. and Riggs, K. B. 1998 Environmental Engineering Science Ambient air PCDD/PCDF concentrations in Montgomery County, Ohio	In September 1995, ambient air concentrations of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF) were measured at five locations in Montgomery County, Ohio. Montgomery County is an industrialized urban area the north and south municipal waste incinerators operated by the county government. Stack emissions tests in 1988, 1994, and 1995 showed that PCDD/PCDF emissions increase dramatically with electrostatic precipitator (ESP) temperature, particularly above 230 +/- C. After the 1994 tests, incinerator improvements to maintain ESP temperatures below 230 +/- C were completed. Ambient air 24-total mass PCDD/PCDF concentrations measured in 1995 ranged from 1.2 pg/m³ (rural location) to 29.7 pg/m³ (Edgemont neighborhood in the city of Dayton). Meteorological conditions, operational data, and chemical mass balance modeling suggest that a polyvinylchloride (PVC) pyrolyzer, and not the municipal waste incinerators, may be the principal source of ambient air PCDD/PCDF concentrations in Montgomery County	Montgomery County, Ohio	Municipal Waste	prior to 1988	Longitudinal, Prospective	Ambient Air: n=25	Ambient Air samples	2 MWI's in this study 6 samples: 2.4km N of MWI(1) 6 samples: 1.6 km E-NE of MWI (1) 6 samples: 0.5 km SW of MWI (1) 6 samples: 1.4 km NE of MWI (2) (sample directly	None Specified	1	Ambient Air sample	1 sample: 13 km west of MWI's	No
154	Fauna	Rumbold, D., Bruner, M., Mihalik, M., and Marti, E. 1997 Environmental Pollution Biomonitoring environmental contaminants near a municipal solid-waste combustor	Tetrachlorodibenzo-p-dioxin (TCDD), tetrachlorodibenzofuran (TCDF) and selected metal concentrations were measured in eggs and nestlings of anhingas (Anhinga anhinga) and white ibises (Eudocimus albus) collected from a colony next to a municipal solid-waste (MSW) combustor and ash landfill. Most of the measured residues, including TCDD, TCDF, arsenic, beryllium, cadmium and nickel, remained at pre-operational levels during the first five years of facility operation. Selenium (in anhingas) and mercury (in both anhingas and ibises) occurred at their lowest concentrations in samples collected during the fifth year of facility operation (Year-5). Alternatively, concentrations of lead in ibis nestlings were highest in Year-1 and Year-5 compared to Year-0. The MSW combustor could neither be ruled out nor confirmed as the source of this lead	West Palm Beach, Florida	Municipal Waste	1989	Longitudinal, Prospective	Anhinga and White Ibis: 81 eggs, 79 nestlings	contents of eggs and whole nestlings (minus bill, legs, gastrointestinal tract and feathers)	"next" to the MWI. Actual locations not stated	None Specified	Baseline data collected	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
144	Fauna	Ramos, L., Eljarrat, E., Hernandez, L. M., Alonso, L., Rivera, J., and Gonzalez, M. J. 1997 Chemosphere Levels of PCDDs and PCDFs in farm cow's milk located near potential contaminant sources in Asturias (Spain). Comparison with levels found in control, rural farms and commercial pasteurized cow's milks	3 months	PCDD/F concentrations	Not specified	Not elaborated.	HRGC/HRMS	Basic Statistical Analysis (mean, s.d), Mass fragmentograms	Cows Milk: 1 sample (or pooled sample) Cows Milk (control): 1 sample (or pooled sample)	PCDD/F levels on milk collected from rural areas were slightly lower than those collected from the MWI	PCDD/F levels on milk collected from rural areas were slightly lower than those collected from the MWI. All the investigated cows milk exhibited PCDD/F levels lower than 6 pg I-TEQs/g fat basis which is the limit value for human consumption in the legislation of certain EU countries.	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
151	Soil	Rimmer, D. L., Vizard, C. G., Pless-Mulloli, T., Singleton, I., Air, V. S., and Keatinge, Z. A. 3-1-2006 Sci.Total Environ. Metal contamination of urban soils in the vicinity of a municipal waste incinerator: one source among many	N/A	Heavy Metals (As, Cr, Cu, Hg, Ni, Zn)	Soil cores (5cm diameter, 5cm depth)	Soil was air dried and any plant material was removed manually and soil was sieved through a 2mm mesh. Soil storage not elaborated.	Atomic absorption spectroscopy, Hg determined by using the cold vapour technique	None stated	Soil: 163	Any effect that the incinerator had on the soils of the surrounding area was not detectable.	Researchers conclude that the effect of the incinerator on soils with generally elevated concentrations could not be detected. No evidence of greater concentrations downwind of the MWI when compared to other directions. Concentrations were typical to those found in other urban areas.	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
153	Ambient Air	Roth, A. J. and Riggs, K. B. 1998 Environmental Engineering Science Ambient air PCDD/PCDF concentrations in Montgomery County, Ohio	2 day sampling period (Sept 18-20) 4-day sampling period (Sept 25-29)	PCDD/PCDF Concentrations	high volume air sampler (General Metal Works GPS-1)	Not elaborated.	VG Autospec gas chromatograph y/high-resolution mass spectrometry	No statistical test performed	25	Approx 70% of PCDD/F levels at the sites located <2km from the incinerator (1.4 and 1.6) were estimated to be directly attributable to the incinerator through a chemical mass balance model (CMBM) Approx 11% of ambient PCDD/F emissions are attributable to the	Ambient air PCDD/F concentrations were less than the US national background concentration at 3 of the 4 sampling locations. 2 of the locations were downwind and close (<2km) to the MWI's. The sampling location with concentrations > the US national background level appeared to be impacted by sources of the MWI's	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
154	Fauna	Rumbold, D., Bruner, M., Mihalik, M., and Marti, E. 1997 Environmental Pollution Biomonitoring environmental contaminants near a municipal solid-waste combustor	5 years	PCDD/F concentrations and heavy metals	samples were placed in commercially obtained chemically-cleaned jars with teflon coated caps	samples were frozen pending chemical analysis	Dioxins and Furans: HRGC/HRMS Inductivly Coupled Plasma Emission Spectrometry (Be, Cd, Pb, Ni) Graphite Furnace Atomic Absorption spectrophotom	ANOVA, nonparametric Mann-Whitney Rank Sum Test, Kruskal-Wallis test	81 egg samples 79 nestling samples	Contribution of the MWI could neither be confirmed nor ruled out	TCDD, TCDF, arsenic, beryllium, cadmium and nickel, remained at pre-operational levels during the first five years of facility operation. Selenium (in anhingas) and mercury (in both anhingas and ibises) occurred at their lowest concentrations in samples collected during the fifth year of facility operation (Year-5). Concentrations of lead in ibis nestlings were highest in Year-1 and Year-5 compared to Year-0. The MSW combustor could neither be ruled out nor	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
165	Vegetation	Schuhmacher, M., Rodriguez-Larena, M. C., Agramunt, M. C., az-Ferrero, J., and Domingo, J. L. 2002 Chemosphere Environmental impact of a new hazardous waste incinerator in Catalonia, Spain: PCDD/PCDF levels in herbage samples	In April 1996 and 1998, the concentrations of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) were determined in 40 herbage samples collected in the neighborhood of a hazardous waste incinerator (HWI) under construction in Constanti (Catalonia, Spain). In April 2000, 20 months after the HWI began operating, herbage samples were again collected at the same sampling points in which samples had been taken in the previous surveys. PCDD/F concentrations ranged between 0.13 and 0.65 ng I-TEQ/kg (dry matter), with a median and mean values of 0.29 and 0.32 ng I-TEQ/kg (dry matter), respectively. The results were compared with those obtained in the 1996 (median, 0.53 ng I-TEQ/kg; mean, 0.61 ng I-TEQ/kg) and the 1998 (median, 0.23 ng I-TEQ/kg; mean, 0.31 ng I-TEQ/kg) surveys. While in the period 1996-1998 a significant decrease (49%, $P < 0.001$) in the mean PCDD/F levels was noted, in the period 1998-2000 an increase of 3% ($P > 0.05$) was found in the concentrations of PCDD/Fs. The analysis of the results suggests two potential hypotheses: either the emissions of PCDD/Fs from the HWI are not negligible, or the current PCDD/F emissions from other sources near the HWI remained at similar levels to those reached in 1998. Anyhow, an exhaustive evaluation of the present data shows an absence of notable PCDD/F contamination by the HWI in the area under its direct influence. It seems also probable that the decline in the atmospheric levels of PCDD/Fs due other emission sources of PCDD/Fs in this area is currently stopped	Catalonia, Spain	Hazardous Waste	1998	Longitudinal, Prospective	Herbage: n=40	Herbage	Urban and rural (actual location not specified) All samples were within 7kms from the incinerator	None Specified	Baseline survey completed in prior study.	N/A	N/A	N/A
166	Soil	Schuhmacher, M., Granero, S., Xifro, A., Domingo, J. L., Rivera, J., and Eljarrat, E. 1998 Chemosphere Levels of PCDD/Fs in soil samples in the vicinity of a municipal solid waste incinerator	Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) were determined in 24 soil samples collected near a municipal solid waste incinerator (Tarragona, Catalonia, Spain). Soil samples were obtained at various sites within 1.5 km from the stack. Total PCDD/F concentrations ranged from 0.225 to 5.80 ng TEQ/kg dry matter (d.m.) with a median value of 0.799 ng TEQ/kg and a mean value of 1.080 ng TEQ/kg. No remarkable PCDD/F contamination was found. The results were consistent and even lower than those reported in other international studies. Principal Component Analysis and hierarchical cluster analysis were used to compare these soil samples with a set of 10 additional samples collected outside the influence of the plant. Principal Component and hierarchical cluster analyses of soils in the vicinity of the incinerator provide patterns of PCDD/Fs quite similar from those obtained in soils collected far from the influence of that facility	Tarragona, Spain	Municipal Waste	1991	Cross sectional	Soil: n=24	Soil	250m 500m 750m 1000m 1500m from the stack	None Specified	Not particularly specified.	Soil	rural area 4-6km from the incinerator	No
176	Soil	Segura-Munoz, S. I., Bocio, A., Trevilato, T. M., Takayanagui, A. M., and Domingo, J. L. 2004 Bull.Environ.Contam Toxicol. Metal concentrations in soil in the vicinity of a municipal solid waste landfill with a deactivated medical waste incineration plant, Ribeirao Preto, Brazil	N/A	Western Region of Riberiao Preto, Brazil	Municipal Waste	1989	Cross sectional	Soil: n=32	Soil	Soil sampled from 0-2000 meters along the 4 transects N, E, W, S	None Specified	Soil: n=6	Soil	Santa Teresa Forest Ecological Station of Ribierao Preto, located at 8kms away from the MWI	No
177	Vegetation	Seike, N., Miwa, T., Otani, T., and Ueji, M. 2005 Shokuhin Eiseigaku Zasshi Levels of dioxins in Japanese fruit in 1999 to 2002 and estimation of their intake	Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) in the surrounding environment (outdoor) and workplace air of two municipal solid waste incinerators (MSWIs, T and M) were characterized and compared. T and M represented two typical municipal solid waste incinerators in the north of Taiwan, which have different processes for controlling the PCDD/F emissions. The results of this study are summarized as follows. (1) The total PCDD/F and the total PCDD/F WHO-TEQ concentrations in the workplace air were 5-13 and 5-15 times higher than those in the outdoor air, respectively. Obviously, it is worthwhile to explore more on health risk assessment for exposure of PCDD/Fs emitted from MSWIs, particularly in the workplace air. (2) Mean total PCDD/F I-TEQ concentrations in the outdoor air ranged between 0.0216 and 0.155 pg I-TEQ/Nm(3) and averaged 0.0783 pg I-TEQ/Nm(3) (0.0828 pg WHO-TEQ/Nm(3)) during two seasons for two MSWIs, which were 6.5-fold higher than that of a remote site (0.0119 pg I-TEQ/Nm(3) or 0.0132 pg WHO-TEQ/Nm(3)) in Taiwan. However, the above outdoor air concentration levels in the MSWIs were still much lower than the air quality limitation of PCDD/Fs (0.6 pg I-TEQ/Nm(3)) in Japan []. (3) PCDFs were the primary toxicity distributors for PCDD/Fs in the outdoor air, since the ratios of PCDDs/PCDFs (I-TEQ) at all sampling sites ranged from 0.180 to 0.492 and were less than unity. (4) The OCDD, OCDF, 1,2,3,4,6,7,8-HpCDD and 1,2,3,4,6,7,8-HpCDF were the four dominant species in both workplace and outdoor air near MSWIs. (5) By spraying water on and wetting both the fly and bottom ashes, the mean total PCDD/F I-TEQ concentration in the workplace air was reduced 86.9% in the T MSWI. The above results indicate an appropriate improving action did inhibit the	Japan	Municipal Waste	N/A	Longitudinal, Prospective	Fruit: n=55 Soil: n=35	Fruit (apple, chestnut, grape, Japanese apricot, Mandarin orange, peach, pear, persimmon, pon-kan orange) Soil	55 fruit samples: <1km of a municipal waste incinerator 35 soil samples: <1km of a municipal waste incinerator	None Specified	Fruit: n=102 Soil: n=58	Fruit (apple, chestnut, grape, Japanese apricot, Mandarin orange, peach, pear, persimmon, pon-kan orange) Soil	102 fruit samples: >1km from a municipal waste incinerator 58 soil samples: >1km from a municipal waste incinerator	No
183	Ambient Air; Soil; Vegetation; Water	Sonich-Mullin, C. 2091 Govt.Reports Announcements.& Index.(GRA.&I), Issue.15., %2091. Feasibility of Environmental Monitoring and Exposure Assessment for a Municipal Waste Combustor: Rutland, Vermont Pilot Study	Final rept The purpose of the multipollutant, multimedia study was to determine levels of contaminants in the ambient air, soil, sediment, water and agricultural products attributable to operation of the municipal waste combustor (MWC) in Rutland, Vermont. Samples were collected between October 1987 and February 1989 at or near locations predicted to have maximum deposition. The measured pollutant concentrations could not be correlated with the emissions or operation of the MWC. Evidence for this conclusion comes from both qualitative and quantitative evaluation of the measured pollutant concentrations in the ambient air and environmental media, as well as comparison with predicted ambient air concentrations of the pollutants using local meteorologic information	Rutland, Vermont	Municipal Waste	1987	Longitudinal	Ambient Air: unspecified Soil: 60 Sediment: 45 Water: 15 Vegetation 24	Ambient Air, Soil, Sediment, water, agricultural products (carrots, potatoes, milk, and grass hay)	Locations were within in depositional range of the MWI	None Specified	Ambient Air: unspecified Soil: unspecified Sediment: unspecified Water: unspecified	Ambient Air, Soil, Sediment, water, agricultural products (carrots, potatoes, milk, and grass hay)	Locations were within in depositional range of the MWI	None Specified

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
165	Vegetation	Schuhmacher, M., Rodriguez-Larena, M. C., Agramunt, M. C., az-Ferrero, J., and Domingo, J. L. 2002 Chemosphere Environmental impact of a new hazardous waste incinerator in Catalonia, Spain: PCDD/PCDF levels in herbage samples	1 month	PCDD/F concentrations	Herbage samples were immediately packed in aluminum foils	Sample were dried at room temperature, kept in double aluminum foil, packed in labeled plastic bags and stored at room temperature until analysis	HRGC/HRMS	Kruskal-Wallis test, multivariate analysis	Herbage: 40	HWI may have contributed to a small local increase in PCDD/Fs	There was a significant reduction in PCDD/F levels from 1996 to 1998. Small significant increase in PCDD/F level from 1998 to 2000 The study shows an absence of a notable PCDD/F contamination by the HWI in the area under its direct influence. Although the plant may have contributed locally to an increase in PCDD/F levels, the HWI is not the only source emitting atmospheric PCDD/F s in this area, and	Junta de Residus, Department of the Environment, Generalitat de Catalunya, Spain	Moderate	Moderate	Moderate	High	Yes
166	Soil	Schuhmacher, M., Granero, S., Xifro, A., Domingo, J. L., Rivera, J., and Eljarrat, E. 1998 Chemosphere Levels of PCDD/Fs in soil samples in the vicinity of a municipal solid waste incinerator	Not specified	PCDD/F concentrations	Not specified	Homogenized soil samples were dried and sieved (2mm mesh)	HRGC/HRMS	Kruskal-Wallis test, multivariate analysis, Principal component analysis	Soil: 24 Soil control group: number not specified	slight contamination around the incinerator	Significant differences between control and study group were only found for OCDF. Analysis presents slight contamination in areas around the incinerator. Comparison to data obtained from other studies suggest a low contamination of soils.	SIRUSA	Moderate	Moderate	Moderate	Moderate	Yes
176	Soil	Segura-Munoz, S. I., Bocio, A., Trevilato, T. M., Takayanagui, A. M., and Domingo, J. L. 2004 Bull.Environ.Contam Toxicol. Metal concentrations in soil in the vicinity of a municipal solid waste landfill with a deactivated medical waste incineration plant, Ribeirao Preto, Brazil	N/A	As, Be, Cd, Cr, Hg, Mn, Ni, Pb, Sn, Tl, V	polyethelene boxes	Storage not elaborated.	As, Be, Cd, Cr, Hg, Pb, Sn, Tl, V: inductivly coupled plasma-mass spectrometry Ni: atomic absorption spectrophotometry with graphic furnace atomization	Kruskal-Wallis rank sum test, multiple comparisons test, Mann-Whitey rank sum test	Soil: 32 Soil Control: 6	The reductions in the soils in the vicinity of the MWI can be attributed to the closure of MWI in 2002	Since the closure of the Medical Waste Incineration Plant the metal concentrations in the soils in the vicinity have decreased with the exception of Mn and V. The levels of Mn and V can be attributed to the Municipal Landfill located in close proximity to the soil sample sites.	FAPESP and CAPES	Moderate	Moderate	Moderate	Moderate	Yes
177	Vegetation	Seike, N., Miwa, T., Otani, T., and Ueji, M. 2005 Shokuhin Eiseigaku Zasshi Levels of dioxins in Japanese fruit in 1999 to 2002 and estimation of their intake	2 years	PCDD/PCDF Concentrations PCB	N/A	Fruits: for apples, pears, Japanese apricot, grapes and persimmons peduncles, cores, and seeds were removed then the fructifications were homogenized in a mixer. For pon-kan oranges, whole fructifications were homogenized in a mixture. For Mandarin orange, chestnuts and peaches the skin	High resolution gas chromatograph equipped with a high resolution mass spectrometer	ANOVA, least significant difference test, *t*-test, Welches test, principal component analysis	Fruits: n=148 Soil: n=87	Authors failed to conclusively link the TEQ of PCDD/F's and coplanar PCBs in apples to either the MWI emissions or the presence of other industrial facilities in the area.	The TEQ of apples collected from near-source areas was significantly higher ($p<0.05$) than that collected from general areas. A PCA revealed that not only MWI's but also PCB's in the environment are associated with the high TEQ in apples.	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
183	Ambient Air; Soil; Vegetation; Water	Sonich-Mullin, C. 2091 Govt.Reports Announcements.& Index.(GRA.&I), Issue.15., %2091. Feasibility of Environmental Monitoring and Exposure Assessment for a Municipal Waste Combustor: Rutland, Vermont Pilot Study	16 months	PCDD/Fs, Metals; PCBs	Various methods	Various storage methods	Various analysis methods	congener profiles, statistical analysis	Ambient Air: unspecified Soil: 60 Sediment: 45 Water: 15 Vegetation 24	The incinerator was not found to be a primary source of pollutants in the area. No correlation was found.	The measured pollutant concentrations could not be correlated with the emissions or operation of the MWC. Evidence for this conclusion comes from both qualitative and quantitative evaluation of the measured pollutant concentrations in the ambient air and environmental media, as well as comparison with predicted ambient air concentrations of the	Not discussed.	High	High	High	High	Yes

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
189	Ambient Air; Soil; Vegetation	Tries, M. A., Ring, J. P., and Chabot, G. E. 1996 Health Phys. Environmental monitoring for a low-level radioactive waste management facility: incinerator operations	An environmental monitoring program has been developed for Harvard University, Southborough campus, to assess the local environmental concentrations of radionuclides released in incinerator effluents. The campus is host to the University's low-level radioactive waste management facility, which consists of 6,000 drum capacity decay-storage buildings; a 250 drum capacity decay-storage freezer; and a controlled-air incinerator. Developmental considerations were based on the characteristics and use of the incinerator, which has a capacity of 8 tons per day and is operated 5% of the time for the volume reduction of Type 0 and Type 4 wastes contaminated with a variety of radionuclides used in biomedical research-some in microsphere form. Monitoring was established for air, leafy vegetation, leaf-litter, and surface soil media. Field sampling was optimized regarding location and time based on the action of atmospheric, terrestrial, and biotic transport mechanisms. Preliminary results indicate transient concentrations of 3H and 125I in vegetation directly exposed to the dispersing plume. Measurable particulate depositions have not been observed	Harvard University, Southborough Campus, MA	Low Level Radioactive Waste Management Facility	N/A	Cross-sectional	Ambient air samples were taken continuously during exclusive burns (incineration of radioactive waste) Vegetation, soil, leaf-litter not particularly specified.	Ambient air, leafy vegetation, leaf-litter and surface soil	4 air stations were placed downwind of the incinerator, while 1 was placed upwind (placement was determined according to average wind direction data from NOAA) vegetation,	None Specified	Ambient air samples were taken continuously Vegetation, soil, leaf-litter not particularly specified.	Ambient air, soil, vegetation, leaf-litter	4 air stations were placed downwind of the incinerator, while 1 was placed upwind (placement was determined according to average wind direction data from NOAA)	No
190	Ambient Air	Valerio, F., Pala, M., Piccardo, M. T., Lazzarotto, A., Balducci, D., and Brescianini, C. 1995 Science of the Total Environment Exposure to airborne cadmium in some Italian urban areas	Three hundred and ninety-five daily airborne particulate samples collected in urban and industrial areas of Genoa and La Spezia, and 46 samples from urban areas of a further 16 Italian towns, provide information for the mean airborne cadmium exposure. The geometrical means for cadmium were the highest near the municipal urban waste incinerator of Genoa and in the industrial area of La Spezia (respectively 9.0 and 5.1 ng/m³). After closure of the incinerator a significant decrease (-96%) in cadmium around the plant was found. In all the urban areas, mean cadmium concentrations ranged from 1.5 to 2.8 ng/m³ and at the rural site of La Spezia the mean cadmium concentration was 0.9 ng/m³. These results agree with those found for other, similar European areas. Traffic and	Genoa	Municipal Waste	N/A	Longitudinal, Prospective	Ambient air: n=88	Ambient air	26 samples 200m from the incinerator 62 samples from locations selected from diffusion models	None Specified	307	Ambient air samples	various sites not under the influence of the MWI	No
195	Soil	Yan, J. H., Xu, M. X., Lu, S. Y., Li, X. D., Chen, T., Ni, M. J., Dai, H. F., and Cen, K. F. 3-1-2008 J.Hazard.Mater. PCDD/F concentrations of agricultural soil in the vicinity of fluidized bed incinerators of co-firing MSW with coal in Hangzhou, China	The concentrations of 17PCDD/F congeners as well as tetra- to octa-homologues were determined in 33 soil samples collected within a radius of 7 km from a municipal solid waste (MSW) incineration plant that is equipped with three fluidized bed incinerators (FBIs) of co-firing MSW with coal in Hangzhou, China. The total PCDD/F concentrations ranged from 0.39 to 5.04 pg I-TEQ g(-1) (54-285 pg g(-1)), with an average and a median value of 1.22 and 0.84 pg I-TEQ g(-1) (105 and 86 pg g(-1)), respectively. A systematic decrease of PCDD/F levels was observed with the increasing distances and with the decreasing downwind frequencies from the plant. The comparisons of homologue and congener patterns and multivariate analysis of soil and flue gas samples strongly indicated that most of the soil samples were influenced by the FBIs. Apart from the incineration plant, historical PCDD/F emissions of hazardous waste incinerator (HWI) and motor vehicles as well as the application of 1,3,5-trichloro-2-(4-nitrophenoxy) benzene (CNP) seemed to play an important role in soil samples adjacent to these potential sources	Hangzhou, China	Municipal Waste	operation of first 2 lines: 2002; full operation: 2003	Cross sectional	Soil: n=30 (agricultural land)	Soil	Samples were collected within a radius of 3km from the stack mainly in the historical prevailing downwind direction (W, S, SE, SSE, SW, NE)	None Specified	Soil: n=3 (agricultural land)	Soil	Samples collected in the least downwind frequency direction of E, 6-7kms from the stack	No
19	Ambient Air	Bobet, E., Berard, M. F., and Dann, T. 1990 Chemosphere The measurement of PCDD and PCDF in ambient air in Southwestern Ontario	For the past two years, Environmental Canada has operated an ambient air monitoring network in Southwestern Ontario, measuring levels of toxic organic compounds on a regular basis. This paper presents the PCDD and PCDF results for the network's first year of operation	Southwestern, Ontario (incinerator in Detroit)	Municipal Waste	1989	Longitudinal, Prospective	Ambient Air: 20	Ambient Air	Sampling sites were located approximately 30kms from the Detroit MWI (Windsor and Walpole Isl.)	None Specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
189	Ambient Air; Soil; Vegetation	Tries, M. A., Ring, J. P., and Chabot, G. E. 1996 Health Phys. Environmental monitoring for a low-level radioactive waste management facility: incinerator operations	3 months	radionuclides	Air: fixed air sampling station Vegetation, Soil and leaf-litter: plastic bags	Not elaborated.	Ambient Air: compound specific detection systems were used (See materials and methods section of document) Vegetation, soils and leaf-litter; SAMPO 90 with HPGe detection system	None stated	Not stated	Transient levels of ^{3}H and ^{125}I were found in vegetation directly exposed to the dispersing plume	Releases are not sufficiently large enough to result in significant long-term buildup of radionuclides in leaf-litter and soil media.	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
190	Ambient Air	Valerio, F., Pala, M., Piccardo, M. T., Lazzarotto, A., Balducci, D., and Brescianini, C. 1995 Science of the Total Environment Exposure to airborne cadmium in some Italian urban areas	4 years	Cd, PAHs	High volume air sampler	Not elaborated.	HRGC/HRMS	ANOVA	Ambient air: 395	Yes	Traffic and the MWI were identified as the main source of Cd in this study.	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
195	Soil	Yan, J. H., Xu, M. X., Lu, S. Y., Li, X. D., Chen, T., Ni, M. J., Dai, H. F., and Cen, K. F. 3-1-2008 J.Hazard.Mater. PCDD/F concentrations of agricultural soil in the vicinity of fluidized bed incinerators of co-firing MSW with coal in Hangzhou, China	2 days	PCDD/F concentrations	Not elaborated.	Soil samples were dried and sieved through a 2mm mesh screen. Refrigerated until analysis.	HRGC/HRMS	Hierarchical cluster analysis, Principal component analysis, multivariate analysis	Soil: 33	Yes, PCDD/F levels can be attributed to incinerator	From the multivariate analysis of homologue patterns that most of the soil samples in the studying area were directly affected by the MWI. Other sources of such as automobiles, Hazardous waste incinerator and the application of pesticides seemed to play and important role in agricultural soils adjacent to these potential sources.	Not discussed.	Moderate	Moderate	Moderate	Moderate	Yes
19	Ambient Air	Bobet, E., Berard, M. F., and Dann, T. 1990 Chemosphere The measurement of PCDD and PCDF in ambient air in Southwestern Ontario	1 year	PAH, PCB, PCDD/F, chlorinated phenols and benzenes, VOCs, PM10	High volume air samplers (glass fiber filters and PUF absorbent traps)	Not elaborated.	GC/MS	Multivariate analysis	Ambient Air: 20	Incinerator not built	Low concentrations in background air samples	Not discussed.					Baseline

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
35	Soil	Cobb, G. P., Feng, Z., and Kendall, R. J. 1993 Toxicological and Environmental Chemistry Correlations between polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in soils from western Washington	Suface soils were sampled as part of an environmental monitoring program in the vicinity of a proposed rotary-kiln municipal waste incinerator. Soils were collected at locations predicted to receive differing particle deposition from the incinerator. Soils collected prior to incinerator operation showed differences in absolute PCDD and PCDF concentrations. However, chemical patterns were quite similar. Concentrations of PCDD and PCDFs were correlated at sampling sites. Data indicate a consistent source of PCDDs and PCDFs in the vicinity of the incinerator prior to initiation of waste burning. These data will allow assessment of incinerator impacts by monitoring chemical concentration and pattern changes at these sampling sites	Skagit County, Washington, USA	Municipal Waste	1988	Cross-sectional, prospective sampling	6 Sample Locations, 1 sample per location per day, over 3 days = 18 total samples	Soil	Determined via atmospheric modelling - sites were located at maximum predicted atmospheric fallout.	None identified.	Background concentrations used but locations not elaborated	unsure	unsure	unsure
37	Ambient Air	Coutinho, M., Ferreira, J., Gomes, P., Mata, P., and Borrego, C. 2001 Chemosphere Atmospheric baseline levels of PCDD and PCDF in the region of Oporto	An external monitoring plan (EMP) is being implemented in the region of Oporto, Portugal, to follow the potential effects of a future incinerator of municipal solid waste. Polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/PCDF) were measured during 1998 and the first semester of 1999, prior to the working up of the incineration unit. The baseline levels obtained through this intensive monitoring work are presented and discussed in the present paper	Oporto, Portugal	Municipal Waste	Not built	Cross Sectional, Prospective	Ambient Air: n=unspecified	Ambient Air	Air samples taken within a radius of 10kms from there the MWI is proposed to be built	None Specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
35	Soil	Cobb, G. P., Feng, Z., and Kendall, R. J. 1993 Toxicological and Environmental Chemistry Correlations between polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans in soils from western Washington	3 Days	PCDD/PCDF Concentrations	Acetone Rinsed Trowels	Teflon Containers	GC/MS	t and f-tests were done to assess correlation between PCDD and PCDF. No statistical tests done to compare sample and control.	18	N/A, this was a baseline establishment study for the incinerator in question.	Baseline sampling of this nature will aid in future monitoring events to assess incinerator impacts.	Skagit Country Department of Public Works and Washington State Department of Ecology					Baseline
37	Ambient Air	Coutinho, M., Ferreira, J., Gomes, P., Mata, P., and Borrego, C. 2001 Chemosphere Atmospheric baseline levels of PCDD and PCDF in the region of Oporto	N/A	PCDD/F concentrations	Not specified	Not elaborated	Not stated	HCA and Basic Statistical analysis	Ambient Air: unspecified	Incinerator not built	PCDD/F levels in Oporto were relatively high with a average corresponding to an urban area with important pollutant sources. Temporal variability of PCDD/F concentrations was also observed.	LIPOR					Baseline

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
71	Fauna	Hippelein, M., Kaupp, H., Dorr, G., and Hutzinger, O. 1996 Chemosphere Baseline contamination assessment for a new resource recovery facility in Germany: Part III: PCDD/Fs, HCB, and PCBs in cow's milk	As part of a program to establish the baseline contamination of the environment in the vicinity of a planned waste incineration plant, 16 cow's milk samples were analysed for polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), hexachlorobenzene (HCB), and polychlorinated biphenyls (PCBs). Four farms were sampled on four occasions spread over one year. The measured concentrations were low compared to literature data and far below the German guidelines and legal limits. The concentrations and contaminant profiles were similar at all farms for all samples. The contaminants in the milk originated largely from atmospheric deposition of the compounds to feed	Augsberg, Germany	Municipal Waste	Not built	Longitudinal	Bovine Milk Samples: N=12	1 liter of bovine milk was taken from the farms milk tank after the morning milking	3 farms were located within a 2.5 km radius of the proposed incineration plant	None Specified	Bovine Milk: n=4	1 liter of bovine milk was taken from the farms milk tank after the morning milking	Sampling site was location 15kms from the proposed location, NW in a rural area removed from major sources of pollutants	No
72	Ambient Air	Hippelein, M., Kaupp, H., Doerr, G., McLachlan, M., and Hutzinger, O. 1996 Chemosphere Baseline contamination assessment for a new resource recovery facility in Germany Part II: Atmospheric concentrations of PCDD/F	The atmospheric levels of PCDD/Fs in both the gas and particle phases were measured continuously over 1 year at 7 sites in the outskirts of Augsburg, Germany, and at a rural site 15 km from the city. The homologue and congener patterns in the total air samples were similar among the different stations and stayed constant throughout the whole year. The PCDD/F levels were about two times higher at the sampling points on the edge of the city than at the remote location. There was a pronounced temporal variability of the total air concentrations, with levels in winter that were 9 times higher than the levels in summer. The gas/particle partitioning was characterised by higher gaseous fractions for more volatile compounds and higher ambient temperatures. It was concluded that the ambient air concentrations of the PCDD/Fs are determined by on-going local and regional emissions, with seasonal (winter) sources contributing the vast majority of the emissions fluxes	Augsberg, Germany	Municipal Waste	Not built	Longitudinal	Ambient Air: samples were taken continuously at 7 sampling sites	Ambient Air	7 sampling sites were located within 2.5kms of the proposed incinerator location	None Specified	Ambient Air: samples were taken continuously at 1 site	Ambient Air	Sampling site was location 15kms from the proposed location, NW in a rural area removed from major sources of pollutants	No
102	Soil; Vegetation	Llobet, J. M., Schuhmacher, M., and Domingo, J. L. 2000 Toxicological and Environmental Chemistry Observations on metal trends in soil and vegetation samples collected in the vicinity of a hazardous waste incinerator under construction (1996-1998)	The temporal variation in metal concentrations in soil and vegetation samples collected in an area of Catalonia (Spain), which will be under the potential influence of a new hazardous waste incinerator was determined. In 1996 and again in 1998, As, Be, Cd, Cr, Hg, Mn, Ni, Pb, Sn, Tl and V were measured in 40 soil and 40 herbage samples collected at 250-4000 m from the facility at the same sampling points. Data of both surveys and the percentages of variation are here presented for all metals. Results are shown according to the main wind directions in the area, as well as distances from the new facility. During the period 1996-1998, a general decrease was noted for most metals. Only the levels of Hg were significantly increased during this period. The present results will be useful for future surveys aimed to evaluate the environmental impact of metals derived from emissions of the new plant	Catalonia, Spain	Hazardous Waste	under construction	Longitudinal, Prospective	Soil: n-31 Herbage: n=31	Soil and Herbage	North: 7 North West: 7 East: 9 South: 8 Samples were collected at 250m, 500m, 1000m, 1500m, 2000m, 2500m, 3000m, 3500m, 4000m	None Specified	Soil: n=9 Herbage: n=9	Soil and Herbage	urban zone near the main population nucleus of the area	No
117	Ambient Air	Mateu, J., Bauza De, M. I. R. A., Forteza, R., Cerda, V., Colom, M., and Oms, M. 1999 Water Air and Soil Pollution Heavy metals in the aerosols collected at two stations in Mallorca (Spain)	An extensive study of the different heavy metals (Fe, mn ni, cr, zn, cd, pb, cu) Present in the atmospheric aerosols collected at two stations in mallorca located in the evirons of a new incinerator plant has been carried out. The aim of this study is to establish the quality of the air surrounding this new msw (Municipal solid waste) Incinerator on the island of mallorca prior to its setting up. Besides, a study of the distribution of the analyzed metals in both the fine (Diameter |1.5 Mum) And	Mallorca, Spain	Municipal Waste	Not built	Cross sectional	Ambient Air: n=not specified (4 3 month sampling periods)	Ambient Air	Samples were collected in the area surrounding a future MWI	None specified	N/A	N/A	N/A	N/A
128	Soil; Vegetation	Nadal, M., Agramunt, M. C., Schuhmacher, M., and Domingo, J. L. 2002 Chemosphere PCDD/PCDF congener profiles in soil and herbage samples collected in the vicinity of a municipal waste incinerator before and after pronounced reductions of PCDD/PCDF emissions from the facility	Congener profiles are the fractional distribution of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) congeners in an environmental release, or in an environmental or biological sample. In 1999, an adaptation to the EU legislation on pollutant emissions from the stack was carried out in an old municipal solid waste incinerator (MSWI) from Montcada (Barcelona, Spain). The main goal of the present study was to determine if the environmental PCDD/F levels in the area under direct influence of the facility were mainly due to PCDD/F emissions from the plant. For this purpose, soil and herbage samples were collected near the MSWI before (1998) and after (2000) the technical improvements were performed. PCDD/F congener profiles were determined and compared with those from samples collected in a suburban area of Constanti (Tarragona, Spain) outside of direct emissions from any MSWI. The results of the present study suggest that the MSWI here assessed is not the main responsible for the environmental PCDD/F concentrations in the area under evaluation. Other PCDD/F emission sources in the same area seem also to have a notable impact on the atmospheric levels of these pollutants	Montcada, Spain	Municipal Waste	N/A	Retrospective	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
71	Fauna	Hippelein, M., Kaupp, H., Dorr, G., and Hutzinger, O. 1996 Chemosphere Baseline contamination assessment for a new resource recovery facility in Germany: Part III: PCDD/Fs, HCB, and PCBs in cow's milk	1 year	PCDD/F concentrations	Not discussed	Not elaborated.	HRGC/HRMS	None stated	Bovine Milk: 12 Bovine Milk (control): 4	No incinerator built (baseline study)	PCDD/F concentrations in the milk were low and lay well below the recommended levels for PCDD/Fs in Germany.	Bayerisches Staatsministerium fur Landesentwiklung					Baseline
72	Ambient Air	Hippelein, M., Kaupp, H., Doerr, G., McLachlan, M., and Hutzinger, O. 1996 Chemosphere Baseline contamination assessment for a new resource recovery facility in Germany Part II: Atmospheric concentrations of PCDD/F	1 year	PCDD/F concentrations	Air samplers (high or low volume not specified)	Not elaborated.	HRGC/HRMS	Prinicpal Component Analysis	Ambient Air: unspecified	No incinerator built (baseline study)	PCDD/F concentrations in the air were relatively homogenous	Bayerisches Staatsministerium fur Landesentwiklung					Baseline
102	Soil; Vegetation	Llobet, J. M., Schuhmacher, M., and Domingo, J. L. 2000 Toxicological and Environmental Chemistry Observations on metal trends in soil and vegetation samples collected in the vicinity of a hazardous waste incinerator under construction (1996-1998)	2 years	Metals: (As, Cd, Cr, Hg, Mn, Ni, Pb, V)	Soil: samples taken from the upper 3cm of soil and scrapped into polyethelene sampling bags Herbage: samples were cut at a height of approx 4cm from the soil and immediately packed into aluminum foil	Soil: not elaborated Herbage: dried at room temperature, kept in double aluminum foil and packed in labeled plastic bags and stored at room temperature until analysis	Soils: As, Cd, Cr, Hg, Mn, Pb, V: inductively coupled plasma spectrometry Ni: atomic absorption spectrometry Herbage: Cd, Hg, Mn, Pb:inductively coupled plasma spectrometry	ANOVA, Kruskal-Wallis test, students t-test	Soil: 31 Herbage: 31	baseline study, no incinerator present	During the time period a general decrease was seen for most metals. Only the levels of Hg were significantly increased during this period.	Generalitat de Catalunya: Junta de Residus					Baseline
117	Ambient Air	Mateu, J., Bauza De, M. I. R. A., Forteza, R., Cerda, V., Colom, M., and Oms, M. 1999 Water Air and Soil Pollution Heavy metals in the aerosols collected at two stations in Mallorca (Spain)	7 months	Heavy Metals (Fe, Zn, Mn, Cu, Ni, Pb, Cr, Cd)	High volume sampler and cascade impactor	Not elaborated.	Sequential plasma emission spectrometer with an AS-90 autosampler	None stated	Not specified (4 3-month sampling periods)	No incinerator built (baseline study)	Concentrations of heavy metals in atmospheric aerosols prior to the running of a new MWI were found to be very low and similar to the values obtained at other Mediterranean stations	Spanish Council for Research in Science					Baseline
128	Soil; Vegetation	Nadal, M., Agramunt, M. C., Schuhmacher, M., and Domingo, J. L. 2002 Chemosphere PCDD/PCDF congener profiles in soil and herbage samples collected in the vicinity of a municipal waste incinerator before and after pronounced reductions of PCDD/PCDF emissions from the facility	4 years	PCDD/F concentrations	N/A	N/A	N/A	N/A	N/A	N/A, the objective of this study was to analyze the congener profiles of vegetation samples collected in previous studies	Authors concluded that emissions for PCDD/F of the MSWI of Montcada are not the only emissions responsible for the presence of the organic pollutants in soil and vegetation samples collected in the area under direct influence of the plant	Entitat Metropolitana del Medi Ambient, Barcelona Spain					Baseline

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
158	Soil	Schuhmacher, M., Granero, S., Llobet, J. M., de Kok, H. A., and Domingo, J. L. 1997 Chemosphere Assessment of baseline levels of PCDD/F in soils in the neighbourhood of a new hazardous waste incinerator in Catalonia, Spain	In order to determine the baseline contamination by polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in an area from Catalonia (Spain), which will be under the influence of a new hazardous waste incinerator, PCDD/F concentrations were measured in 40 soil samples collected in the vicinity of the facility now under construction. Thirty samples represented rural soils and 10 samples urban soils. PCDD/F concentrations ranged between 0.08-8.4 ng I-TEQ/kg for rural soils and 0.63-24.2 ng I-TEQ/kg for urban soils. The mean value for the 40 samples was 1.64 ng I-TEQ/kg (dry matter). The current PCDD/F levels and profiles are comparable to those found in soils from other countries. The PCDD/F concentrations found in this study show that at present the contamination by PCDD/F in soils of the examined area is rather low	Catalonia, Spain	Hazardous Waste	N/A	Cross sectional	Soil: n=40 (30 rural areas, 10 urban areas)	Soil	Samples were collected within 7km from the incinerator	None Specified	N/A	N/A	N/A	N/A
160	Vegetation	Schuhmacher, M., Domingo, J. L., Llobet, J. M., Mueller, L., Suenderhauf, W., and Jager, J. 1998 Chemosphere Baseline levels of PCDDs in vegetation samples collected in the vicinity of a new hazardous waste incinerator in Catalonia, Spain	Concentrations of polychlorinated dibenzo-p-dioxins (Pcdd) And dibenzofurans (Pcdf) Were analysed by gc in 40 vegetation samples collected in the neighbourhood of a hazardous waste incinerator (Hwi) Now under construction (Catalonia, spain). Samples were collected at various sites within a radius of 7 km from the facility. Ten samples belonged to an urban area and 30 samples to a rural area. Pcdd/f concentrations ranged between 0.24-1.22 Ng i-teq/kg (Dry matter), With a median and mean values of 0.53 And 0.61 Ng i-teq/kg (Dry matter), Respectively. Principal component analysis (Pca) Provided a two-dimensional model which would explain 67.0% Of the variance in the data. The present results will be useful to determine the environmental impact of the hwi in future assessments of the plant./Chemistry	Catalonia, Spain	Hazardous Waste	under construction	Cross sectional	Vegetation: n=40	vegetation samples (boutelova gracilis)	within a radius of 7km from the incinerator	None Specified	N/A	N/A	N/A	N/A
161	Soil; Vegetation	Schuhmacher, M., Agramunt, M. C., Rodriguez-Larena, M. C., az-Ferrero, J., and Domingo, J. L. 2002 Chemosphere Baseline levels of PCDD/Fs in soil and herbage samples collected in the vicinity of a new hazardous waste	The construction in Constanti (Catalonia, Spain) of a new hazardous waste incinerator (HWI), which is the first one in Spain, finished in 1999. In order to determine the temporal variation (1996-1998) in the concentrations of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) in the vicinity of the new HWI, 40 soil and 40 herbage samples were collected (1998) at the same sampling points in which samples had been taken two years before (1996). Each sample was analyzed for PCDDs and PCDFs by high resolution gas chromatography/high resolution mass spectrometry. In the 1996 survey, PCDD/F concentrations in soils ranged from 0.13 to 24.20 ngl-TEQ/kg (d.m.), with median and mean values of 0.67 and 1.68 ngl-TEQ/kg (d.m.), respectively. In the present study, PCDD/F concentrations ranged from 0.12 to 17.20 ng I-TEQ/kg (d.m.), with a median value of 0.75 ng I-TEQ/kg (d.m.) and a mean value of 1.59 ng I-TEQ/kg (d.m.). In turn, in the present study PCDD/F concentrations in vegetation	Catalonia, Spain	Hazardous Waste	1998	Longitudinal, Prospective	Soil: n=40 Herbage: n=40 (30 rural areas, 10 urban areas)	Soil and Herbage	Urban and rural (actual location not specified)	None Specified	N/A	N/A	N/A	N/A
184	Soil	Stenhouse, I. A. and Badsha, K. S. 1990 Chemosphere PCB, PCDD and PCDF concentrations in soils from the Kirk Sandall/ Edenthorpe/ Barnby Dun Area (England, UK)	This study presents baseline concentrations of pcbs, pcdds and pcdfs around the site proposed for a chemical waste incinerator near doncaster. They add to the sparse urban and rural background data available for concentrations of these compounds in the uk. The results show pcb levels between 2 and 11 ppb and i-teq values between 3 and 20 ppt for the dioxins and furans. These values indicate that the area has, at present, a very low contamination of these species and is comparable with a rural environment	Doncaster	Chemical Waste Incineratro (not built)	N/A	Cross sectional	Soil: n=12	Soil Samples	Samples collected from the prevailing wind direction from undisturbed soils within a radius of 2.5 km from the proposed location of the incinerator	None Specified	N/A	N/A	N/A	N/A
47	Soil; Vegetation	Domingo, J. L., Granero, S., and Schuhmacher, M. 2000 Journal of Environmental Science and Health - Part A Toxic/Hazardous Substances and Environmental Engineering Assessment of the environmental impact of PCDD/Fs in the vicinity of a municipal waste incinerator: Congener profiles of PCDD/Fs in soil and vegetation samples	Municipal solid waste (MSW) incineration is a component of integrated waste management in many countries. Among typical MSW incinerator contaminants, polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) are of especial concern. Measuring PCDD/F concentrations in soil and vegetation samples collected in the vicinity of a MSW incinerator can be a suitable method to determine the environmental impact of PCDD/F emissions from MSW incinerators. However, these concentrations can be increased by the presence of other emission sources of PCDD/Fs in the area under evaluation. In the present study, we have used PCDD/F congener profiles from soil and vegetation samples collected near an old MSW incinerator (Montcada, Barcelona, Spain) in 1996, 1997 and 1998 in order to estimate the direct contribution of the plant to the environmental levels of PCDD/Fs in the area under potential influence of the facility. PCDD/F congener profiles were compared with those from samples collected in the vicinity of another MSW incinerator, as well as with those from an area which is not under the direct influence of any MSW incinerator. From an accurate inspection of the PCDD/F congener profiles, it can be concluded that emissions of PCDD/Fs from the MSW incinerator of Montcada are neither the only nor the main responsible for the presence of these pollutants in soil and vegetation samples collected in the area under direct influence of the plant	Montcada, Spain	Municipal Waste	N/A	Retrospective	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
158	Soil	Schuhmacher, M., Granero, S., Llobet, J. M., de Kok, H. A., and Domingo, J. L. 1997 Chemosphere Assessment of baseline levels of PCDD/F in soils in the neighbourhood of a new hazardous waste incinerator in Catalonia, Spain	N/A	PCDD/F concentrations	N/A	Soil samples were collected form the upper 5cm of the solum. They were dried and sieved though a 2mm mesh	GC/MS	Kruskal-Wallis test, multivariate analysis, PCA	Soil: 40	baseline study, no incinerator present	Present contamination levels of PCDD/F in the area are rather low.	Not discussed.					Baseline
160	Vegetation	Schuhmacher, M., Domingo, J. L., Llobet, J. M., Mueller, L., Suenderhauf, W., and Jager, J. 1998 Chemosphere Baseline levels of PCDDs in vegetation samples collected in the vicinity of a new hazardous waste incinerator in Catalonia, Spain	Not specified	PCDD/F concentrations	Immediately packed in aluminum foils	Dried at room temperature and kept in double aluminum foil and packed in labeled plastic bags until analysis	HRGC/HRMS	multivariate analysis, Principal component analysis	Vegetation: 40	baseline study, no incinerator present	PCDD/F levels in vegetation samples collected in the urban area were significantly higher (p<0.01) higher than those found in samples taken in the rural area.	Generalitat de Catalunya: Junta de Residus					Baseline
161	Soil; Vegetation	Schuhmacher, M., Agramunt, M. C., Rodriguez-Larena, M. C., az-Ferrero, J., and Domingo, J. L. 2002 Chemosphere Baseline levels of PCDD/Fs in soil and herbage samples collected in the vicinity of a new hazardous waste	1 month	PCDD/F concentrations	Not specified	Soil: samples were sieved (2mm), dried until analysis Herbage: dried at room temperature and stored until analysis	GC/MS	ANOVA, multivariate analysis, Principal component analysis	Soil: n=40 Herbage: n=40	baseline study, no incinerator present	According to the present (1998) and the previous (1996) levels of PCDD/Fs found in soils and vegetation, the area under potential influence of the new facility shows a rather low contamination by these compounds. The current results should be useful to	Junta de Residus, Department of the Environment, Generalitat de Catalunya, Spain					Baseline
184	Soil	Stenhouse, I. A. and Badsha, K. S. 1990 Chemosphere PCB, PCDD and PCDF concentrations in soils from the Kirk Sandall/ Edenthorpe/ Barnby Dun Area (England, UK)	1 day	PCBs, PCDD/F concentrations	hexane washed aluminum foil	Soil samples were dried to constant weight at ambient air temperature, ground and sieved through a 18 mesh (1mm) sieve and homogenized	HRGC/HRMS	None stated	Soil: 12	baseline study, no incinerator present	Results show a very low contamination associated with soil samples collected from the area of the proposed incinerator.	Not discussed.					Baseline
47	Soil; Vegetation	Domingo, J. L., Granero, S., and Schuhmacher, M. 2000 Journal of Environmental Science and Health - Part A Toxic/Hazardous Substances and Environmental Engineering Assessment of the environmental impact of PCDD/Fs in the vicinity of a municipal waste incinerator: Congener profiles of PCDD/Fs in soil and vegetation samples	4 years	PCDD/F concentrations	N/A	N/A	N/A	N/A	N/A	N/A, the objective of this study was to analyze the congener profiles of vegetation samples collected in previous studies	Authors concluded that emissions for PCDD/F of the MSWI of Montcada are not the only emissions responsible for the presence of the organic pollutants in soil and vegetation samples collected in the area under direct influence of the plant	Entitat Metropolitana del Medi Ambient, Barcelona Spain					Study does not conform to our grading scheme

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
48	Soil; Vegetation	Domingo, J. L., Granero, S., and Schuhmacher, M. 2001 Chemosphere Congener profiles of PCDD/Fs in soil and vegetation samples collected near to a municipal waste incinerator	Recently, we measured the concentrations of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) in soil and herbage samples collected in the vicinity of a municipal solid waste incinerator (MSWI) from Tarragona (Catalonia, Spain). Since these concentrations could be increased by the presence of other emission sources of PCDD/Fs in the same area in which the MSWI is placed, the main goal of the present study was to determine the PCDD/F congener profiles in the soil and vegetation samples collected in 1996 and again in 1997 near to the facility and to compare with those from samples collected in a close area outside of direct emissions of the plant. From an accurate inspection of the PCDD/F congener profiles, it was concluded that PCDD/F emissions from the MSWI here examined are neither the only nor the main responsible for the presence of PCDD/Fs in the samples of environmental matrices collected in the area under direct influence of the plant	Tarragona, Spain	Municipal Waste	N/A	Retrospective	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
48	Soil; Vegetation	Domingo, J. L., Granero, S., and Schuhmacher, M. 2001 Chemosphere Congener profiles of PCDD/Fs in soil and vegetation samples collected near to a municipal waste incinerator	1 year	PCDD/F concentrations	N/A	N/A	N/A	N/A	N/A	N/A, the objective of this study was to analyze the congener profiles of vegetation samples collected in previous studies	Authors concluded that emissions for PCDD/F of the MSWI of Tarragona are not the only emissions responsible for the presence of the organic pollutants in soil and vegetation samples collected in the area under direct influence of the plant	Entitat Metropolitana del Medi Ambient, Barcelona Spain					Study does not conform to our grading scheme

APPENDIX C-3B

Environmental Monitoring - Excluded

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
7	Worker Ambient Air	Almaguer, D. and Driscoll, R. J. 1991 Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-88.-314.-2152., 27.pages., 8.references., %1991. Health Hazard Evaluation Report No. HETA-88-314-2152, Lutheran Medical Center, Brooklyn, New York	In response to a confidential request from employees of the Lutheran Medical Center (SIC-8062), Brooklyn, New York, a study was conducted of exposure to noxious odors from the hospital's pathological waste incinerator. The employees suggested that infectious waste disposal practices and the manner in which the incinerator was operated were unnecessarily exposing the workers to the hazardous materials. Two of eight interviewed workers in the Nursery, Pediatrics, and Materials Delivery Departments regularly experienced nausea, headaches, dry scratchy throat, and burning eyes. Tracer gas evaluations indicated that reentrainment of incinerator/scrubber stack emissions was possible under certain conditions but there were no documented overexposures to any of the chemicals evaluated. No written respiratory protection program was in place at the time of the survey. The authors conclude that there were no documented overexposures to any of the substances evaluated, but reentrainment of incinerator/scrubber stack emissions is possible under certain meteorological conditions. The authors recommend the establishment of a written respiratory protection program. The pathological waste incinerator was shut down shortly after this survey; recommendations are provided should the incinerator ever be restarted	Lutheran Medical Center, Brooklyn, NY, USA	Medical Waste Incinerator	N/A	Cross Sectional	30 air samples Tracer gas analysis	Air samples and tracer gas samples were taken	Samples were taken at various locations throughout the medical facility. Samples collected included both general area air samples and personal breathing zone air samples	None Specified	N/A	N/A	N/A	N/A
11	Vegetation	Bache, C. A., Elfving, D. C., and Lisk, D. J. 1992 Chemosphere Cadmium and lead concentration in foliage near a municipal refuse incinerator	Biosis copyright: Biol abs. Whereas landfilling still remains a necessary means of disposing of municipal solid waste, construction of refuse incineration facilities is increasing in the united states. There is currently much public opposition to building such incinerators because of health concerns about toxicants emitted as particulates and gases from the stacks. Cadmium and lead are typically present at significant levels in refuse incinerator fly ash. In this study these heavy metals were determined in tree foliage sampled at increasing distances in the vicinity of a municipal refuse incineration plant equipped with electrostatic precipitators to reduce emitted particulates. There was a high degree of correlation between diminishing foliar concentration of cadmium and lead and the logarithm of the distance north and south of the incinerator, the only directions in which foliar samples could be collected. Sources of these metals in refuse and factors which affect the magnitude of their deposition.	New York, USA	Municipal Waste	1985	Cross Sectional	Foliage Samples: n=21	Mixed foliage, staghorn sumac, hard maple, quaking aspen and quackgrass	Samples were taken north and south within 900 meters from the MWI	None Specified	N/A	N/A	N/A	N/A
12	Vegetation	Bache, C. A., Gutenmann, W. H., Rutzke, M., Chu, G., Elfving, D. C., and Lisk, D. J. 1991 Archives of Environmental Contamination and Toxicology Concentrations of metals in grasses in the vicinity of a municipal refuse incinerator	There is currently much public opposition to the construction of municipal refuse incinerators in the United States owing to health concerns about emitted toxicants. In this study, 19 elements and polychlorinated biphenyls (PCBs) were determined in grasses sampled upwind and downwind from a municipal refused incinerator which had no emission control devices. Concentrations of Cd, Mo, Hg, Zn, Fe, and Pb were generally highest immediately adjacent to the incinerator. Foliar concentration of Hg decreased linearly with distance downwind. Polychlorinated biphenyls were not detectable in any of the grass samples possibly due to their thermal destruction during incineration or greater dispersion because of their higher vapor pressure	United States	Municipal Waste	1983	Cross Sectional	Grass: n=20	Grass Samples	Samples were taken 100 meters to 900 meters upwind and downwind from the MWI	None Specified	N/A	N/A	N/A	N/A
13	Worker Ambient Air	Bakoglu, M., Karademir, A., and Ayberk, S. 2004 J.Occup.Health An evaluation of the occupational health risks to workers in a hazardous waste incinerator	A study was conducted to evaluate the health impact of airborne pollutants on incinerator workers at IZAYDAS Incinerator, Turkey. Ambient air samples were taken from two sampling points in the incinerator area and analyzed for particulate matter, heavy metals, volatile and semi-volatile organic compounds (VOCs and SVOCs) and dioxins. The places where the maximum exposure was expected to occur were selected in determining the sampling points. The first point was placed in the front area of the rotary kiln, between the areas of barrel feeding, aqueous and liquid waste storage and solid waste feeding, and the second one was near the fly ash transfer line from the ash silo. Results were evaluated based on the regulations related to occupational health. Benzene, dibromochloropropane (DBCP) and hexachlorobutadiene (HCBD) concentrations in the ambient air of the plant were measured at levels higher than the occupational exposure limits. Dioxin concentrations were measured as 0.050 and 0.075 pg TEQ.m(-3), corresponding to a daily intake between 0.007 and 0.01 pg TEQ. kg body weight(-1).day (-1). An assessment of dioxin congener and homologue profiles suggested that gaseous fractions of dioxin congeners are higher in front of the rotary kiln, while most of them are in particle-bound phases near the ash conveyor. Finally, the necessity of further studies including occupational health and medical surveillance assessments on the health effects of the pollutants for the workers and the general population in such an industrialized area was emphasized	Turkey	Hazardous Waste	Dec-97	Cross Sectional	Ambient Air: 2 pooled samples	Ambient Air	Ambient air sampled were taken at the front area of the rotary kiln, and near the transfer line.	None Specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
7	Worker Ambient Air	Almaguer, D. and Driscoll, R. J. 1991 Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-88.-314.-2152., 27.pages., 8.references., %1991. Health Hazard Evaluation Report No. HETA-88-314-2152, Lutheran Medical Center, Brooklyn, New	4 days	particulates, respirable particulates, metals, VOCs	samples were collected in sampling pumps	Not elaborated	ICP-AES and GC/MS	Basic quantitative analysis	30 air samples Tracer gas analysis	Yes, chemical concentrations were assumed to be from the incinerator	Tracer-gas evaluation showed that reentrainment of incinerator/scrubber stack emissions was possible under certain meteorological conditions (when the wind was blowing the incinerator emissions into the fresh air intake for the hospital). Indoor air quality complaints sometimes occurred when a large number of airborne contaminants are present at concentrations well below the industrial criteria. However, the low concentrations found	Not discussed.	Low	Low	Moderate	Low	No
11	Vegetation	Bache, C. A., Elfving, D. C., and Lisk, D. J. 1992 Chemosphere Cadmium and lead concentration in foliage near a municipal refuse incinerator	1 month	Pb and Cd concentrations	Not elaborated.	Samples were air dried at room temperature and milled to a powdery consistency	Atomic Absorption Analysis	Analysis of regression	Foliage Samples: 21	Yes, results indicate that the MWI resulted in the deposition of Pb and Cd in areas surrounding the facility	There was a high degree of correlation between diminishing foliar concentration of cadmium and lead and the logarithm of the distance north and south of the incinerator, the only directions in which foliar samples could be collected.	Not discussed.	Low	Low	Moderate	Moderate	No
12	Vegetation	Bache, C. A., Gutenmann, W. H., Rutzke, M., Chu, G., Elfving, D. C., and Lisk, D. J. 1991 Archives of Environmental Contamination and Toxicology Concentrations of metals in grasses in the vicinity of a municipal refuse incinerator	1 month	Metals: (As, Cd, Cr, Hg, Mn, Ni, Pb, V)	Plants were cut with scissors	Samples were air dried at room temperature	ICAP, ICP	Linear regression	Grass: 20	Yes, study indicates that a MWI without emission control devices can result in the deposition of heavy metals in the vicinity of the incinerator.	Concentrations of Cd, Mo, Hg, Zn, Fe, and Pb were generally highest immediately adjacent to the incinerator. Foliar concentration of Hg decreased linearly with distance downwind. Polychlorinated biphenyls were not detectable in any of the grass samples possibly due to their thermal destruction during incineration or greater dispersion because of their higher vapor pressure	N/A	Low	Low	Moderate	Moderate	No
13	Worker Ambient Air	Bakoglu, M., Karademir, A., and Ayberk, S. 2004 J.Occup.Health An evaluation of the occupational health risks to workers in a hazardous waste incinerator	1 month	PM, Heavy metals, VOCs, SVOCs, PCDD/Fs	PM and Heavy metals: glass fiber filters VOCs and SVOCs: activated carbon columns PCDD/Fs: glass fiber filters	Not elaborated.	PM and Heavy metals: ICP/AES VOCs and SVOCs: GC/MSD PCDD/Fs: HRGC/HRMS	Basic statistical analysis, I-TEQ values	Ambient Air: 2	Yes, levels of chemical receptors were assumed to be correlated to the incinerator	Results show that the concentrations of some organic chemicals in the ambient air of the incinerator are higher than the occupational health limits. This implies that medical surveillance in the plant should be considered.	Not discussed.	Low	Low	Moderate	Moderate	No

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
24	Worker Ambient Air	Burton, N. C., Esswein, E. J., and Marlow, D. 1992 Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-91.-261.-2245., 33.pages., 54 references., %1992. Health Hazard Evaluation Report No. HETA-91-261-2245, Metropolitan Sewer	In response to a confidential request from an employee, a health hazard evaluation was conducted at the Metropolitan Sewer District, Mill Creek Facility (SIC-4952) in Cincinnati, Ohio. Concern had been expressed regarding exposure to sulfur-dioxide (7446095), nitrogen oxides, inorganic acids, metals, dioxins, furans, and bacteria in the sludge dewatering and incineration buildings. There were approximately 60 employees on three shifts with the potential for exposure in the sewer sludge dewatering and incineration buildings. Personal breathing zone and area air samples were taken along with surface wipe and bulk materials samples. Contaminant concentrations did not exceed current environmental evaluation criteria for the substances investigated. Health complaints were not reported by employees at the time of the site visits. The authors conclude that concentrations of cadmium (7440439), chromium (7440473), lead (7439921), nickel (7440020), and quartz (14808607) in dewatered sludge and surface dusts represented potential ingestion and inhalation hazards. The authors recommend measures to prevent contact with contaminated materials	Cincinatti, Ohio, USA	Municipal Waste	burners were first used in 1934 (assume improvement of pollution abatement technologies since then)	Cross Sectional	3 Bulk samples of depositions 1 sample of dewatered sludge 2 Short term area air samples 4 Matched pairs of area air Samples 17 personal breathing zone air samples 13 area air	3 Bulk samples of depositions 2 Short term area air samples 4 Matched pairs of area air Samples 17 personal breathing zone air samples 13 area air samples	Samples were taken on the incinerator building wall, sixth floor, stairwell, dewatered sludge, personal breathing zone samples. Surface wipe samples were taken in the filter press area, sixth	None Specified	N/A	N/A	N/A	N/A
25	Soil; Vegetation	Capuano, F., Cavalchi, B., Martinelli, G., Pecchini, G., Renna, E., Scaroni, I., Bertacchi, M., and Bigliardi, G. 2005 Chemosphere Environmental prospection for PCDD/PCDF, PAH, PCB and heavy metals around the incinerator power plant of Reggio Emilia town (Northern Italy) and surrounding main roads	Samples of soil, sediment and pine needles from the Reggio Emilia area were analysed in order to estimate the environmental pollution caused by an MSWI. PCDD/PCDF, PCB, PAH and metals were analysed in the collected samples. The data obtained showed relatively low pollution levels. Indeed, the PCDD/PCDF and PCB data were comparable to the values usually found in the grazing areas of the European Union countries. Metal concentrations in soils and sediments may be related to local geological occurrences and to agricultural activities. PAH values are significantly lower than the limit values set by the Italian law. copyright 2004 Elsevier Ltd. All rights reserved	Reggio Amilia, Italy	Municipal Waste	N/A	Cross-Sectional	Soil: n=15 Pine Needles: n=5	Soil and Pine Needles	Location was about $10kms^2$	None Specified	N/A	N/A	N/A	N/A
27	Ambient Air	Chang, M. B., Chi, K. H., Chang, S. H., and Chen, Y. W. 2004 Atmospheric Environment Measurement of PCDD/F congener distributions in MWI stack gas and ambient air in northern Taiwan	To meet the emission standards that become more and more stringent, the waste incinerators are commonly equipped with various air pollution control devices. Gas/particulate phase distribution of polychlorinated dibenzo-p-doxin and furan (PCDD/F) in stack gas could be much different when different control technologies are applied. This study evaluates PCDD/F congener distributions at the stack gas of a municipal waste incinerator (MWI) and ambient air in northern Taiwan via stack gas and ambient air sampling and analysis. Ambient air samples were taken in the vicinity area of a large-scale MWI for measuring PCDD/F concentrations and partitioning gas/particulate phase from November 1999 through January 2001. Stack gas samples of the MWI were taken during the period of ambient air sampling. The PCDD/F concentrations measured in fall and winter seasons are significantly higher than those measured in summertime. In addition, the results obtained on gas/particulate partitioning of ambient air samples indicate that the particulate-phase PCDD/Fs account for more than 80% of the total concentration. Nevertheless, the gas/particulate partitioning of stack gas PCDD/F sample was completely different from that of the ambient air samples. The gas-phase PCDD/Fs account for more than 85% of the total concentration in MWI stack gas. This study also indicates that as the chlorination level of PCDD/F congeners increases, the percentage of PCDD/Fs existing in gas phase decreases in either ambient air or stack gas of MWI. Furthermore, the temperature in ambient air also affects the percentage of particle-	Taiwan	Municipal Waste	1995	Longitudinal	Ambient Air: n=24	Ambient Air	1.4km upwind 1.7km downwind 1.7km downwind 3.1km downwind	No PCDD/F emission sources in nearly 20km vicinity	N/A	N/A	N/A	N/A
34	Ambient Air; Soil	Cheng, P. S., Hsu, M. S., Ma, E., Chou, U., and Ling, Y. C. 2003 Chemosphere Levels of PCDD/FS in ambient air and soil in the vicinity of a municipal solid waste incinerator in Hsinchu	Levels of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) were determined in twenty-one ambient air samples, eight soil samples and two stack gas samples, collected near or in a municipal solid waste incinerator (MSWI) in Hsinchu, Taiwan. A systematic decrease of PCDD/Fs in the ambient air from the northeastern area was observed. PCDD/Fs levels measured in the ambient air range from 0.058 to 0.127 pg-TEQ/m3. Higher PCDD/Fs levels in the ambient air were found during winter. In addition, PCDD/Fs levels measured in the soil range from 0.524 to 5.02 pg-TEQ/g d.m. Principal component analysis (PCA) and hierarchical cluster analysis (HCA) did not provide sufficient evidence that the environmental PCDD/Fs contamination was caused by emissions from the Hsinchu MSWI. An unknown PCDD/Fs source was proposed using congener profile analysis and supported by both PCA and HCA	Hsinchu, Tawian	Municipal Waste	2001	Longitudinal	Ambient Air: n=21 Soil: n= 8	Ambient Air and Soil Samples	Samples were taken within 5kms from the MWI	None Specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
24	Worker Ambient Air	Burton, N. C., Esswein, E. J., and Marlow, D. 1992 Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-91.-261.-2245., 33.pages., 54 references., %1992. Health Hazard Evaluation Report No. HETA-91-261-2245, Metropolitan Sewer	2 months	Gases and Vapors, VOCs, Metals, Respirable Silica and Cristobalite, Inorganic acids, PCDD/Fs	Draeger gas detection system with colormetric tubes, charcoal tubes, mixed-cellulose ester filters, silica gel tubes, 3x3 soxhlet-extracted cotton gauze samples	Not elaborated. Surface wipes were placed in a glass samples container and equipped with a Teflon-lined lid	x-ray diffraction, GC/MS, ICP-AES, ion chromatography.	Basic quantitative analysis	3 Bulk samples of depositions 1 sample of dewatered sludge 2 Short term area air samples 4 Matched pairs of area air Samples 17 personal breathing zone air samples 13 area air	Yes, chemical concentrations were assumed to be from the incinerator	Concentrations of contaminants in the surface, area, and personal samples did not exceed established occupational evaluation criteria. Employees did not report any health complaints to NIOSH investigators during two site visits	Not discussed.	Low	Low	Moderate	Low	No
25	Soil; Vegetation	Capuano, F., Cavalchi, B., Martinelli, G., Pecchini, G., Renna, E., Scaroni, I., Bertacchi, M., and Bigliardi, G. 2005 Chemosphere Environmental prospection for PCDD/PCDF, PAH, PCB and heavy metals around the incinerator power plant of Reggio Emilia town (Northern Italy) and surrounding main roads	unspecified	PCDD/F, PAH, PCBs and Heavy Metals	Not elaborated.	Pine needle samples were frozen until analysis	GC/MS and ICP, AAS	None stated	Soil: 15 Pine needles: 5	No, there was no evidence of recent contamination due to significant pollutants from combustion processes	The data obtained showed relatively low pollution levels. Indeed, the PCDD/PCDF and PCB data were comparable to the values usually found in the grazing areas of the European Union countries. Metal concentrations in soils and sediments may be related to local geological occurrences and to agricultural activities. PAH values are significantly lower than the limit values set by the Italian law	Not discussed.	Low	Low	Moderate	Low	No
27	Ambient Air	Chang, M. B., Chi, K. H., Chang, S. H., and Chen, Y. W. 2004 Atmospheric Environment Measurement of PCDD/F congener distributions in MWI stack gas and ambient air in northern Taiwan	1 year	PCDD/F concentrations	Ambient Air: high-volume air samplers with glass fiber filters and PUF plugs	Ambient Air: filter storage not discussed	HRGC/HRMS	gas/particulate phase distribution	Ambient Air: 24	Yes, PCDD/F levels in ambient air can be correlated to incinerator emissions	This study also indicates that as the chlorination level of PCDD/F congeners increases, the percentage of PCDD/Fs existing in gas phase decreases in either ambient air or stack gas of MWI. Furthermore, the temperature in ambient air also affects the percentage of particle-bound dioxins. As the ambient air temperature decreases by 10degreesC, the percentage of PCDD/Fs in particulate phase increases around 20%. PCDFs account for about 80%	National Science Council of the Republic of China	Low	Low	Moderate	Moderate	No
34	Ambient Air; Soil	Cheng, P. S., Hsu, M. S., Ma, E., Chou, U., and Ling, Y. C. 2003 Chemosphere Levels of PCDD/FS in ambient air and soil in the vicinity of a municipal solid waste incinerator in Hsinchu	1 year	PCDD/F concentrations	Ambient Air: High volume air samplers	Not elaborated	HRGC/HRMS	PCA and HCA analysis	Ambient Air: 21 Soil: 8	PCA and HCA did not provide sufficient evidence that the environmental PCDD/F contamination was caused by emissions from the MWI	PCDD/Fs levels measured in the ambient air range from 0.058 to 0.127 pg-TEQ/m3. Higher PCDD/Fs levels in the ambient air were found during winter. In addition, PCDD/Fs levels measured in the soil range from 0.524 to 5.02 pg-TEQ/g d.m. Principal component analysis (PCA) and hierarchical cluster analysis (HCA) did not provide sufficient evidence that the environmental PCDD/Fs contamination was caused by emissions from the Hsinchu	National Science Council of the Republic of China	Low	Low	Moderate	Moderate	No

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
40	Ambient Air	Coutinho, M., Pereira, M., and Borrego, C. 2007 Chemosphere Monitoring of ambient air PCDD/F levels in Portugal	As part of a monitoring program conducted by IDAD--Institute for Environment and Development and supported by regional municipal solid waste (MSW) management authorities, dioxin concentrations in ambient air were measured in three regions of Portugal: Porto, Lisbon and Madeira. These independent studies were performed with the intention of providing data as a basis for the evaluation of potential impacts of the operation of recently built MSW incinerators. Thus, 170 samples were collected in nine different sites from January 1999 till present. The measured levels revealed an extremely variable content of PCDDs/PCDFs depending both on the area and the season of the year. Samples taken in Porto and Lisbon reveal a similar homologue structure even if concentrations measured in the Porto region are significantly greater. Data from Madeira is characteristic of a remote site with some of the congeners concentrations below the detection limit	Porto, Lisbon and Madeira, Portugal	3 Municipal Waste Incinerators	1998-2000	Longitudinal	Ambient Air: n=170	Ambient Air	Samples were taken in areas that were assumed to be under the influence of the MWIs	None Specified	N/A	N/A	N/A	N/A
43	Soil; Vegetation	Deister, U. and Pommer, R. 1991 Chemosphere Distribution of PCDD/F in the vicinity of the hazardous waste incinerator at Schwabach	The distribution of PCDD/F and a selection of heavy metals in the surrounding area of the Hazardous Waste Incinerator (HWI) at Schwabach has been determined. The PCDD/F concentrations measured in soil, grass and lettuce samples are compared to modeling studies realized by the TUV Bayern	Schwabach	Hazardous waste	N/A	Cross Sectional	Soil and plant: n=13	Soil and plant samples	Samples were taken 350 meters to 750 meters from the HWI chimney	None Specified	N/A	N/A	N/A	N/A
46	Ambient Air	Di, Filippo P., Riccardi, C., Gariazzo, C., Incoronato, F., Pomata, D., Spicaglia, S., and Cecinato, A. 2007 J.Environ.Monit. Air pollutants and the characterization of the organic content of aerosol particles in a mixed industrial/semi-rural area in central Italy	Both regulated and unregulated air pollutants were detected during an intensive seasonal sampling campaign in a mixed industrial/semi-rural area on the outskirts of Rome, Italy, at two sites located opposite a hospital waste incinerator, downwind according to the direction of the prevailing local winds. Concentrations of pollutants were significantly lower than in urban atmospheres. The composition of particulate organic material indicated a heavy biogenic impact, accompanied by a lower contribution from petroleum-related processes. Both PAH and nitro-PAH group compositions of particulates were used to assess the nature and relative importance of sources. Both sites showed that different and diffuse sources contributed to local pollution with a significant contribution from traffic, proving that the hospital waste incinerator was not the main pollution source in this area. Among unregulated compounds, a series of positional isomers of nitro-PAHs and other organic compounds associated with particulate matter were investigated. In particular, 1- and 3-nitrophenanthrene identification was carried out, and they proved to be the most abundant nitro-PAHs	Malagrotta, Italy	Hospital Incinerator	N/A	Cross Sectional	Ambient Air: unknown amount of samples (continuous sampling at 2 sampling locations)	Ambient Air	Sample site 1 was approx 1.5 km B of the incinerator stack. Sample site 2 was approx 1.5kms S of the stack	None Specified	N/A	N/A	N/A	N/A
49	Soil	Domingo, J. L., Schuhmacher, M., Muller, L., Rivera, J., Granero, S., and Llobet, J. M. 8-28-2000 J.Hazard.Mater. Evaluating the environmental impact of an old municipal waste incinerator: PCDD/F levels in soil and vegetation samples	In order to determine the temporal variation in the levels of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in the vicinity of an old municipal solid waste incinerator (MSWI) (S. Adria del Besos, Barcelona, Spain), 24 soil and vegetation samples were collected at the same sampling points in which samples had been taken 1 year before. Each sample was analyzed for PCDDs and PCDFs by high-resolution gas chromatography/high-resolution mass spectrometry. While in the previous study PCDD/F concentrations in soil ranged from 1.22 to 34. 28 ng I-TEQ/kg (median and mean values: 9.06 and 12.24 ng I-TEQ/kg), in the present study, PCDD/F levels ranged from 1.33 to 54.23 ng I-TEQ/kg (median and mean values: 11.85 and 14.41 ng I-TEQ/kg). On the other hand, in the previous study, PCDD/F levels in vegetation ranged from 0.33 to 1.98 ng I-TEQ/kg (median and mean values: 0.58 and 0.70 ng I-TEQ/kg), whereas in the present study, PCDD/F levels ranged from 0.32 to 2.52 ng I-TEQ/kg (median and mean values: 0.82 and 0.97 ng I-TEQ/kg). During the last 12 months, PCDD/F levels increased in 16 of the 24 soil samples and in 17 of the 24 vegetation samples analyzed. However, no significant differences in the median I-TEQ concentrations of both studies were found either in soil or vegetation samples	San Adria del Besos, Barcelona, Spain	Municipal Waste	1975	Longitudinal, Prospective	Soil: n=24 Herbage: n=24	Soil and Herbage	250m, 500m, 750m, 1000m, 1500m, 3000m from the stack in the directions of NE, NW, S	None Specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
40	Ambient Air	Coutinho, M., Pereira, M., and Borrego, C. 2007 Chemosphere Monitoring of ambient air PCDD/F levels in Portugal	5 years	PCDD/F concentrations	Air samplers with a glass fiber filter and PUFs	Not elaborated	HRGC/HRMS	TEQ values, HCA, and Statistical analysis	Ambient Air: 170	Yes, concentrations of PCDD/Fs seem to be assumed to be from the MWI	The measured levels revealed an extremely variable content of PCDD/PCDFs depending both on the area and the season of the year. Samples taken in Porto and Lisbon reveal a similar homologue structure even if concentrations measured in the Porto region are significantly greater. Data from Madeira is characteristic of a remote site with some of the congeners concentrations below the detection limit	LIPOR, Valorsul, Vlaor Ambiente	Low	Low	Moderate	Moderate	No
43	Soil; Vegetation	Deister, U. and Pommer, R. 1991 Chemosphere Distribution of PCDD/F in the vicinity of the hazardous waste incinerator at Schwabach	N/A	PCDD/F concentrations, and heavy metals	Soil Samples were collected with a core drill pipe	Not elaborated	HRGC/HRMS	TEQ calculations	Soil and plant: n=13	Yes, concentrations in the soil surrounding the HWI indicate that the levels are beyond the background levels of rural regions in Germany	The concentrations in PCDD/Fs and heavy metals in soils surrounding the HWI indicate that the concentrations ranges are beyond the background levels of rural regions in Germany but are below the levels in industrialized urban regions. The measurements so not confirm the modeling study by the TUV Bayern. Additionally other local sources such as adjacent motorways have to be considered.	N/A	Low	Low	Moderate	Moderate	No
46	Ambient Air	Di, Filippo P., Riccardi, C., Gariazzo, C., Incoronato, F., Pomata, D., Spicaglia, S., and Cecinato, A. 2007 J.Environ.Monit. Air pollutants and the characterization of the organic content of aerosol particles in a mixed industrial/semi-rural area in central Italy	8 days	O3, CO, Nox, SO2, PM10, PM2.5, *n*-alkanes, PAH, nitro-PAHs	High and Low volume air samplers	Not elaborated.	HRGC/HRMS	Basic Statistical Analysis	Ambient Air: unspecified	Hospital waste not the main source of pollution in the area	Both sampling sites showed that different and diffuse source contributed to local pollution with a significant contribution from traffic, proving that the Hospital waste incinerator was not the main pollution source in this area.	A.M.A.S.p.A., Rome Italy	Low	Low	Moderate	Moderate	No
49	Soil	Domingo, J. L., Schuhmacher, M., Muller, L., Rivera, J., Granero, S., and Llobet, J. M. 8-28-2000 J.Hazard.Mater. Evaluating the environmental impact of an old municipal waste incinerator: PCDD/F levels in soil and vegetation samples	1 year	PCDD/F concentrations	Soil: collected from the upper 3-4cm and kept into polyethelene bags Herbage: samples obtained by cutting 4cm from the soil and immediately packed in aluminum foils	Soils: were dried and homogenized and sieved through a 2mm mesh screen Herbage: dried at room temperature, kept in a double aluminum foil and labeled plastic bags	HRGC/HRMS	ANOVA, Pearson correlation, multivariate analysis, principal component analysis	Soil: 24 Herbage: 24	Yes levels of PCDD/Fs in soil were correlated to the MWI	PCDD/F levels in soil and herbage samples collected near the MWI increased slightly during the 12 months. The differences in the median I-TEQ values did not reach the level of statistical significance. There are concerns about the levels of PCDD/F levels in contaminated soils. It is expected that the implementation of new technologies in the incinerator will reduce the PCDD/F levels within the vicinity of the MWI	City Council of Barcelona, Spain	Low	Low	Moderate	Moderate	No

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
51	Vegetation	Domingo, J. L., Schuhmacher, M., Meneses, M., Granero, S., Llobet, J. M., and De Kok, H. A. M. 1999 Journal of Environmental Science and Health - Part A Toxic/Hazardous Substances and Environmental Engineering Monitoring dioxins and furans near an old municipal solid waste incinerator: Temporal variation in vegetation	To determine the temporal variation in the levels of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) in vegetation grown near an old municipal solid waste incinerator (Montcada, Barcelona, Spain), 24 herbage samples were collected at the same sampling points in which samples had been taken one year before. While in the previous survey PCDD/F concentrations ranged from 1.07 to 3.05 ng I-TEQ/kg (dry matter) (median value: 1.88 ng I-TEQ/kg, mean value: 1.92 ng I-TEQ/kg), in the current samples PCDD/F levels ranged from 0.75 to 1.95 ng I-TEQ/kg (dry matter) (median value: 1.27 ng I-TEQ/kg, mean value: 1.30 ng I TEQ/kg). An individual comparison between PCDD/F concentrations in samples collected in both studies shows a decrease in all the sampling points with an average reduction of 32.3%. This reduction can be due to general abatement actions for PCDD/F emissions	Montcada, Spain	Municipal Waste	1975	Longitudinal, Prospective	Vegetation: n=24	vegetation samples (*boutelova gracilis)* 120-150g (dry weight). Vegetation was cut approx 4cm from the soil	100, 250, 500, 750, 1000, 1500, 2000, 3000 meters from the stack in the 3 main wind directions S, NE, NW	None Specified	N/A	N/A	N/A	N/A
52	Vegetation	Domingo, J. L., Bocio, A., Nadal, M., Schuhmacher, M., and Llobet, J. M. 2002 J.Environ.Monit. Monitoring dioxins and furans in the vicinity of an old municipal waste incinerator after pronounced reductions of the atmospheric emissions	In order to get an overall picture of the environmental impact of an old municipal solid waste incinerator (MSWI) from S. Adria del Besos (Barcelona, Catalonia, Spain), a monitoring program addressed at determining the levels of a number of pollutants in the vicinity of the facility was initiated in 1998. In March 1999, an adaptation was carried out due to EU legislation on pollutant emissions from the stack. As a result, emissions of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) were notably reduced, and a significant (30%) decrease was found in the levels of PCDD/F in herbage samples collected in the vicinity of the MSWI. In March 2001, herbage samples were collected at the same sampling points and the PCDD/F levels measured again. The current PCDD/F concentrations range from 0.23 to 1.43 ng I-TEQ kg(-1) (dry matter), with median and mean values of 0.58 and 0.66 ng I-TEQ kg(-1) (dry matter), respectively, while in the 2000 survey the PCDD/F concentrations ranged from 0.22 to 1.20 ng I-TEQ kg(-1) (dry matter), with median and mean values of 0.57 and 0.61 ng I-TEQ kg(-1) (dry matter), respectively. Although the current PCDD/F concentrations in herbage samples are comparable to those found in recent surveys carried out in various places of Catalonia, an exhaustive evaluation of the data, including principal component analysis, indicates that other emission sources of PCDD/Fs also have a notable environmental impact on the area under direct influence of the MSWI	San Adria del Besos, Barcelona, Spain	Municipal Waste	1975	Longitudinal, Prospective	Herbage: n=20	Herbage	250m, 500m, 750m, 1000m, 1500m, from the stack in the directions of NE, NW, S	None Specified	N/A	N/A	N/A	N/A
53	Soil; Vegetation	Domingo, J. L., Schuhmacher, M., Llobet, J. M., Muller, L., and Rivera, J. 2001 Chemosphere PCDD/F concentrations in soil and vegetation in the vicinity of a municipal waste incinerator after a pronounced decrease in the emissions of PCDD/Fs from the facility	Emission of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) by municipal solid waste incinerators (MSWI) is an issue of great concern. In 1997, an adaptation to the EU legislation on pollutant emissions from the stack was carried out in an MSWI from Tarragona (Catalonia, Spain). As a result, PCDD/F emissions were significantly reduced. The aim of this study was to determine the current levels of PCDD/Fs in soil and vegetation samples collected near the facility and to compare these levels with those obtained in previous surveys (1996 and 1997). In the period 1997-1999, PCDD/F concentrations in vegetation samples were significantly decreased (60%). By contrast, the levels of PCDD/Fs in soil samples increased slightly (14%, P > 0.05) during the same period. An exhaustive analysis of the present data indicates that other emission sources of PCDD/Fs have also a notable environmental impact on the area under direct influence of the MSWI	Tarragona, Spain	Municipal Waste	1991	Longitudinal, Prospective	Soil: n=24 Herbage: n=24	Soil and Herbage	250m, 500m, 750m, 1000m, 1250m, 1500m from the stack in the 4 main wind directions (NE, NW, SE, SW)	None Specified	N/A	N/A	N/A	N/A
54	Soil	Domingo, J. L., Schuhmacher, M., Granero, S., Llobet, J. M., and de Kok, H. A. 1999 Arch.Environ.Contam Toxicol. PCDD/F levels in the vicinity of an old municipal solid waste incinerator: temporal variation in soils	In order to determine the temporal variation in the levels of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in soils in the vicinity of an old municipal solid waste incinerator (Montcada, Barcelona, Spain), in 1997 we collected 24 soil samples at the same sampling points in which samples were taken 1 year before. Each sample was analyzed for PCDDs and PCDFs by GC/MS. While in the previous study PCDD/F concentrations ranged from 0.30 to 44.26 ng TEQ/kg (dry matter), (median and mean values: 3.52 and 6.91 ng TEQ/kg), in the present study PCDD/F levels ranged from 0.15 to 29.27 ng TEQ/kg (median and mean values: 2.56 and 4.47 ng TEQ/kg). PCDD/F concentrations decreased in 14 of the 24 soil samples, while the remaining 10 samples showed increases of different orders. No statistically significant differences in PCDD/F levels according to the main wind directions in the area were noted. In both surveys, the highest PCDD/F concentrations were found 750 m from the stack to the south. The current levels of PCDD/Fs in soils, as well as those found in the previous survey are similar or even lower than PCDD/F concentrations reported for soil samples taken near to municipal solid waste incinerators from different places	Montcada, Spain	Municipal Waste	1975	Longitudinal, Prospective	Soil: n=24	Squares of soil 5m x 5m were established as sampling sites. Each sample consisted of 5 samples (one from the center of the square and 4 the	100, 250, 500, 750, 1000, 1500, 2000, 3000 meters from the stack in the 3 main wind directions S, NE, NW	None Specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
51	Vegetation	Domingo, J. L., Schuhmacher, M., Meneses, M., Granero, S., Llobet, J. M., and De Kok, H. A. M. 1999 Journal of Environmental Science and Health - Part A Toxic/Hazardous Substances and Environmental Engineering Monitoring dioxins and furans near an old municipal solid waste incinerator: Temporal variation in vegetation	1 month	PCDD/F concentrations	samples collected and immediately packed in aluminum foil	Samples were dried at room temperature, kept in double aluminum foils and packed in labeled plastic bags until analysis	GC/MS	ANOVA	24	Yes (PCA performed)	the comparison of the 1996 and 1997 samples show a decrease in all sampling points with an average reduction of 32.3%. This reduction can be due to the general abatement actions for PCDD/F emissions	Entitat Metropolitana del Medi Ambient, Barcelona Spain	Low	Low	Moderate	Moderate	No
52	Vegetation	Domingo, J. L., Bocio, A., Nadal, M., Schuhmacher, M., and Llobet, J. M. 2002 J.Environ.Monit. Monitoring dioxins and furans in the vicinity of an old municipal waste incinerator after pronounced reductions of the atmospheric emissions	2 years	PCDD/F concentrations	Herbage: samples obtained by cutting 4cm from the soil and immediately packed in aluminum foils	Herbage: dried at room temperature, kept in a double aluminum foil and labeled plastic bags	HRGC/HRMS	Kruskal-Wallis test, multivariate analysis, Principal component analysis	Herbage: 24	The MWI is not the primary source of PCDD/F contamination in the area	On average, in the period of 1999-2000 PCDD/F stack emissions from the MWI were notably reduced (more than 100x), the decreases found in herbage samples were only 30% during the same time, and insignificant in the period 2000-2001. Therefore the current environmental levels of PCDD/Fs in the vicinity of the MWI are not mainly due to emission sources of PCDD/Fs other than the MWI	City Council of Barcelona, Spain	Low	Low	Moderate	Moderate	No
53	Soil; Vegetation	Domingo, J. L., Schuhmacher, M., Llobet, J. M., Muller, L., and Rivera, J. 2001 Chemosphere PCDD/F concentrations in soil and vegetation in the vicinity of a municipal waste incinerator after a pronounced decrease in the emissions of PCDD/Fs from the facility	3 years	PCDD/F concentrations	Soil: not elaborated Herbage: cut at about 4cm from the soil and immediately packed in aluminum foils	Soil: sieved through a 2mm mesh screen to achieve homogenous grain distribution and dried Herbage: dried at room temperature and kept in aluminum foil	HRGC/HRMS	Kruskal-Wallis Test, Mann-Whitney test. Multivariate analysis	Soil: 24 Herbage: 24	Yes, but authors state that PCDD/F levels in soils and herbage are clearly influenced by other factors	PCDD/F concentration increased in some instanced but did not reach the level of statistical significance. The decreases of PCDD/F levels were statistically significant The decreases in PCDD/F concentrations did not match the reduction of the stack PCDD/F emissions (after new technology was introduced) so the authors concluded that the area was under the influence of other sources of PCDD/F emissions	SIRUSA	Low	Low	Moderate	Moderate	No
54	Soil	Domingo, J. L., Schuhmacher, M., Granero, S., Llobet, J. M., and de Kok, H. A. 1999 Arch.Environ.Contam Toxicol. PCDD/F levels in the vicinity of an old municipal solid waste incinerator: temporal variation in soils	1 year	PCDD/F concentrations	polyethelene sampling bags	Soil samples were dried, homogenized, and sieved through a 2-mm mesh screen and divided into 2 subsamples	GC/MS	Kruskal-Wallis test, multivariate analysis, Principal component analysis	Soil: 24	Yes, PCDD/F levels can be attributed to incinerator	PCDD/F concentrations decreased in 14/24 samples and the remaining 10 showed increases. No statistically significant changes/differences in the PCDD/F levels according to the main wind directions were noted. The current levels of PCDD/Fs are similar or even lower than those reported for soils in the vicinity of other MWIs.	Entitat Metropolitana del Medi Ambient, Barcelona Spain	Low	Low	Moderate	Moderate	No

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
55	Soil; Vegetation	Domingo, J. L., Schuhmacher, M., Agramunt, M. C., Llobet, J. M., Rivera, J., and Muller, L. 2002 Environ.Int. PCDD/F levels in the neighbourhood of a municipal solid waste incinerator after introduction of technical improvements in the facility	In 1998 and 1999, the concentrations of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) were determined in soil and herbage samples collected in the vicinity of an old municipal solid waste incinerator (MSWI) (S. Adria del Besos, Barcelona, Spain). Just after the 1999 collection, an adaptation to the EU legislation on pollutant emissions from the stack was carried out in this facility. The purpose of the present study was to determine the current concentrations of PCDD/Fs in soil and herbage samples collected in the neighbourhood of the MSWI and to compare these concentrations with those obtained in the 1998 and 1999 surveys. During the period 1998-1999, an increase of 31% (P>.05) was found in the median PCDD/F levels in soils, while a reduction of 40% (P>.05) was observed in the period 1999-2000. Similarly, in the period 1998-1999 an increase of 41% (P>.05) was found in the levels of PCDD/Fs in vegetation, while a 30% decrease (P<.05) was seen in the period 1999-2000. Although after introduction of the technical improvements in the MSWI a notable reduction in the levels of PCDD/Fs in soil and vegetation has been noted, the median decreases have not been as great as it could be expected according to the very pronounced reductions in PCDD/F emissions from the stack. It indicates that other emission sources of PCDD/Fs also have a notable impact on the area under direct influence of the MSWI	San Adria del Besos, Barcelona, Spain	Municipal Waste	1975	Longitudinal, Prospective	Soil: n=23 Herbage: n=23	Soil and Herbage	250m, 500m, 750m, 1000m, 1500m, 3000m from the stack	None Specified	N/A	N/A	N/A	N/A
56	Soil; Vegetation	Domingo, J. L., Schuhmacher, M., Granero, S., and de Kok, H. A. 2001 Environ.Monit.Assess. Temporal variation of PCDD/PCDF levels in environmental samples collected near an old municipal waste incinerator	In 1996 and 1997, the levels of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) were determined in soil and herbage samples taken from 24 sites in the vicinity of an old municipal solid waste incinerator (Montcada, Barcelona, Spain). To determine the temporal variation in the concentrations of PCDD/Fs, recently 24 soil and 24 herbage samples were again collected at the same sampling points and analyzed for PCDD/F levels. In the current survey, PCDD/F concentrations in soils ranged between 0.06 and 127 ng I-TEQ kg(-1) (dry matter), with median and mean values of 4.80 and 9.95 ng I-TEQ kg(-1) (dry matter), respectively. In turn, the levels of PCDD/Fs in herbage samples ranged from 0.40 to 1.94 ng I-TEQ kg(-1) (dry matter), with median and mean values of 0.86 and 0.95 ng I-TEQ kg(-1) (dry matter), respectively. The comparison with the data obtained in 1996 and 1997 show that while PCDD/F concentrations in herbage samples decreased substantially during the last two years, no significant differences in the levels of PCDD/Fs in soils were noted. On the other hand, the potential intake of polluted soils from the vicinity of the plant would not imply any significant health risk for the general population living in the area under influence of the facility	Montcada, Spain	Municipal Waste	1975	Longitudinal, Prospective	Soil: n=24 Herbage: n=24	Soil and Herbage	100m, 250m, 500m, 750m, 1000m, 1500m, 2000m, 3000m from the stack in the directions of NE, NW, S	None Specified	N/A	N/A	N/A	N/A
58	Worker Ambient Air	Esswein, E. J. and Tepper, A. 1994 Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-91.-0366.-2453., 34.pages., 38.references., %1994. Health Hazard Evaluation Report No. HETA-91-0366-2453, Delaware County Resource	In response to a confidential request, an investigation was made of possible hazardous working conditions at the Delaware County Resource Recovery Facility (SIC-4053), Chester, Pennsylvania. The facility was a waste to energy incinerator employing 91 persons. The facility incinerated municipal solid waste and refuse derived fuel to produce electrical power. The request was made in response to concern regarding exposure to lead (7439921), incinerator ash dust, and heat stress. Health concerns included ear, nose and throat problems, eye irritation, and skin rash. During the initial visit, lead and other metals were found in settled dust throughout the facility. Lead, chromium (7440473), cadmium (7440439), and nickel (7440020) were present on lunch tables and on workers' hands. During a follow up visit, full shift personal air monitoring was conducted. The greatest concentrations of lead were found in bulk, wipe and air samples. Personal breathing samples taken showed that lead concentrations were well below the OSHA Permissible Exposure Limit of 50 micrograms/cubic meter. A potential for excessive heat exposure was found on the fifth and sixth floor of the facility. Safety hazards cited during this visit included improper practices regarding personal protective equipment and inadequate personal hygiene practices such as handwashing. The authors conclude that a possible occupational health hazard existed due to heat exposure in some areas of the facility. The presence of metal in dust on workers' hands and surfaces presented a risk of ingestion	Chester, Pennsylvania, USA	Municipal Waste	1991	Cross-Sectional, Prospective	34 air samples; undetermined number of surface samples	Air, Dust	Inside the incinerator.	Expected to impacted by incinerator.	Background carpet samples	Dust	Taken at hotel room.	None anticipated.
60	Ambient Air	Farinha, M. M., Freitas, M. C., and Almeida, S. M. 2004 Journal of Radioanalytical and Nuclear Chemistry Air quality control monitoring at an urban and industrialized area	Air particulate matter analysis has been performed since 1999, within a contract for air quality monitoring of an urban waste incinerator. Air collection was made with Gent samplers, which collect size-fractionated aerosol samples in three sampling sites. Samples were analyzed by instrumental neutron activation analysis (INAA) and proton induced X-ray emission (PIXE). In this study some INAA results are discussed. PM₁₀ mass concentrations are compared with the limit values for human health protection regulated by the European Council Directive 1999/30/CE. Weekend day and weekday samples are compared concerning As, Co, Fe, K, La, Na, Sb, Sc, Se and Zn mean concentrations collected at Bobadela for 1999. Enrichment factors are also presented. Enrichments were found for As, Sb, Se and Zn for both fractions in the three sampling sites. In order to quantify the evolution for the 1999-2001 period, basic statistics was performed for the enriched elements	Lisbon, Portugal	Municipal Waste	1999	Cross Sectional	Ambient Air: unknown amount; of sample (continuous sampling at 3 sampling locations)	Ambient Air	Sampling sites were all within 5kms from the MWI	None Specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
55	Soil; Vegetation	Domingo, J. L., Schuhmacher, M., Agramunt, M. C., Llobet, J. M., Rivera, J., and Muller, L. 2002 Environ.Int. PCDD/F levels in the neighbourhood of a municipal solid waste incinerator after introduction of technical improvements in the facility	2 years	PCDD/F concentrations	Soil: not elaborated Herbage: cut at about 5cm from the soil and immediately packed in aluminum foils	Soil: sieved through a 2mm mesh screen to achieve homogenous grain distribution and dried Herbage: dried at room temperature and kept in aluminum foil	HRGC/HRMS	ANOVA, multivariate analysis, Principal component analysis	Soil: 23 Herbage: 23	Incinerator is not the only source of soil and herbage contamination in the area	PCDD/F levels in soil and herbage samples collected near the MWI decreased (-40% in soils; -30% in herbage) since the introduction of the technological improvement in the plant, these decreases were only significant for herbage ($p<0.05$). The decreases in the concentrations of PCDD/F were not as pronounced as the decreases from stack emissions, this suggests that other emission sources of PCDD/F have a notable impact	Not discussed.	Low	Low	Moderate	Moderate	No
56	Soil; Vegetation	Domingo, J. L., Schuhmacher, M., Granero, S., and de Kok, H. A. 2001 Environ.Monit.Assess. Temporal variation of PCDD/PCDF levels in environmental samples collected near an old municipal waste incinerator	2 years	PCDD/F concentrations	Soil: collected from the upper 3-4cm and kept into polyethelene bags Herbage: samples obtained by cutting 4cm from the soil and immediately packed in aluminum foils	Soils: were dried and homogenized and sieved through a 2mm mesh screen Herbage: dried at room temperature, kept in a double aluminum foil and labeled plastic bags	GC/MS	Kruskal-Wallis test, Mann-Whitney test, multivariate analysis, Principal component analysis	Soil: 24 Herbage: 24	Incinerator is not the only source of soil and herbage contamination in the area	No significant increases or decreases were found in the vicinity of the MWI. The increases and decreases could be best explained by atmospheric PCDD/F changes because the technical characteristics of the MWI did not change during the study period.	Entitat Metropolitana del Medi Ambient, Barcelona Spain	Low	Low	Moderate	Moderate	No
58	Worker Ambient Air	Esswein, E. J. and Tepper, A. 1994 Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-91.-0366.-2453., 34.pages., 38.references., %1994. Health Hazard Evaluation Report No. HETA-91-0366-2453, Delaware County Resource	1 year	Pb, Cr, Cd, Ni, respirable dust	Air - Microfiber filter attached to vacuum.; Surface Wipes - Hexane wetted cotton gauze pads; Chair and carpet - microvacuum.	Air - glass cartridge; Surface Wipes - sealed container.	ICP/MS	None	N/A	Low to medium levels of metals found throughout the facility, including the main office and tabletops.	Inhalation exposure was below applicable OSHA PELs and NIOSH RELs. Ingestion of dust is possible hazard for employees having skin contact with incinerator ash or who fail to wash their hands before eating/smoking.	NIOSH	Low	Moderate	High	Low	No
60	Ambient Air	Farinha, M. M., Freitas, M. C., and Almeida, S. M. 2004 Journal of Radioanalytical and Nuclear Chemistry Air quality control monitoring at an urban and industrialized area	3 years	PM2.5 and PM10 (trace metals)	Gent collector	Not elaborated.	Instrumental Neutron Activation Analysis (INAA) Proton Induced X-ray Emission (PIXE)	Basic statistical analysis	Ambient Air: unspecified	The effects of 3 years under operation is visible but the impact is reduced due to its positioning within an industrialized area and proximity to major roads.	Only annual limits for PM10 were exceeded in Sample site 2 (closest to incinerator) in 2000 and 2001 (all other stayed below). As, Co, Fe, K, La, Na, Sb, Sc, Se, Zn were emitted on average more on weekdays then weekends. Not possible to compare the effect of the start of the MWI in the area because no data were obtained before the start of the MWI for reference.	Not discussed.	Low	Low	Moderate	Moderate	No

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
61	Rain; Snow	Feng, X., Melander, A. P., and Klaue, B. 2000 Water, Air, & Soil Pollution Contribution of Municipal Waste Incineration to Trace Metal Deposition on the Vicinity	Because municipal solid waste incineration is one potential source of air pollution, the incineration industry has provoked great public concern, especially for areas within 10-20 km of an incinerator. However, little work has been done to evaluate whether an incinerator significantly contributes pollutants to nearby areas. Rain and snow samples were collected at eight locations distributed in a semi-circular pattern radiating out in the prevailing wind direction from the Claremont incinerator, New Hampshire, U.S.A. Sodium, Mg, K, Ca, Fe, Al, B, Sr, Ba, Pb, Cr, Cd, V, Ni, Mn, As, Co, Cu, and Zn were analyzed in the solutions of rain and snow and in particulate fractions of rain samples. Principal component analysis was used to identify the most important sources of atmospheric deposition in an attempt to identify the contribution of heavy metal deposition due to the incinerator. Analyses show that the predominant sources of metal deposition are very different for fall and winter. The most important source of metals for the rain samples collected in fall 1996 is soil dust, but for the snow samples collected in the winter 1997 is probably coalfired fly ash. The Claremont incinerator contributes less than 20% of the total variance of the elemental concentrations	Clairmont, New Hampshire, USA	Municipal Waste	1987	Longitudinal	Rain: n=8 Snow: n=19	Rain and Snow	Rain: 1.7kms to 12kms from the incinerator Snow: 1.7 kms to 15kms from the incinerator	None specified	N/A	N/A	N/A	N/A
66	Soil	Floret, N., Lucot, E., Badot, P. M., Mauny, F., and Viel, J. F. 2007 Chemosphere A municipal solid waste incinerator as the single dominant point source of PCDD/Fs in an area of increased non-Hodgkin's lymphoma incidence	Since 1971, a municipal solid waste incinerator (MSWI) with high dioxin emission levels has been in operation in Besancon, France. We recently found a 2.3-fold risk of non-Hodgkin's lymphoma in the highest exposure zone using a Gaussian-type dispersion model as a proxy for dioxin exposure. However, the sources of PCDD/Fs in this area are a matter of controversy. The aim of this survey was therefore to examine the nature of the PCDD/F soil contamination in the surroundings of the MSWI to characterize whether more than one potential emission source could explain the presence of the PCDD/Fs. PCDD/F congener profiles were determined in 75 soil samples collected in the vicinity of the MSWI. They were compared according to the most environmentally impacted zones and to various spatial contrasts. PCDD/F concentrations ranged from 0.25 to 28.06 pg WHO-TEQ g(-1). Two different clustering algorithms identified the same main cluster (consisting of 73 samples). The remaining two soil samples composed either one, or two clusters. All clusters showed similar congener profiles. Moreover, no contrast was observed for congener distributions between complex and simple topographies, inside and outside the city boundary, the two most and the two least exposed areas, reflecting a common fingerprint. Congener profiles indicate that the area under influence of the MSWI is not subject to other point sources of PCDD/Fs. Since, the most polluting combustion chambers were recently shut down and replaced by a new one with up-to-date pollution control, slowly decreasing dioxin concentrations in the soils are to be	Besancon, France	Municipal Waste	1971	Cross-sectional, prospective	75	Soil	Within ~10-15 km radius. Sampling locations based on Gaussian diffusion model to identify areas of high to low emissions impact.	None identified.	No control group.	N/A	N/A	N/A
70	Fauna; Water	Hinzman, R. L., Adams, S. M., and Ashwood, T. L. 2096 Govt.Reports Announcements.& Index.(GRA.&I), Issue.13, %2096. Third report on the Oak Ridge K-25 Site Biological Monitoring and Abatement Program for Mitchell Branch	Environmental Sciences Division Publication No. 4305. Sponsored by Department of Energy, Washington, DC As a condition of the modified National Pollutant Discharge Elimination System (NPDES) permit issued to the Oak Ridge Gaseous Diffusion Plant (ORGDP; now referred to as the Oak Ridge K-25 Site) on September 11, 1986, a Biological Monitoring and Abatement Program (BMAP) was developed for the receiving stream (Mitchell Branch or K-1700 stream). A biological monitoring plan was submitted for Mitchell Branch, Poplar Creek, Poplar Creek Embayment of the Clinch River and any unnamed tributaries of these streams. The objectives of BMAP are to (1) demonstrate that the effluent limitations established for the Oak Ridge K-25 Site protect and maintain the use of Mitchell Branch for growth and propagation of fish and other aquatic life and (2) document the effects on stream biota resulting from operation of major new pollution abatement facilities, including the Central Neutralization Facility (CNF) and the Toxic Substances Control Act (TSCA) incinerator. The BMAP consists of four tasks: (1) toxicity monitoring; (2) bioaccumulation monitoring; (3) assessment of fish health; and (4) instream monitoring of biological communities, including benthic macroinvertebrates and fish. This document, the third in a series, reports on the results of the Oak Ridge K-25 Site BMAP; it describes studies that were conducted over various periods of time between June 1990 and December 1993, although monitoring conducted outside this time period is included, as appropriate	Oak Ridge, Tennessee, USA	Hazardous Waste	Not Available	Longitudinal	Fish: unspecified Wildlife: unspecified	Fish, clams and Wildlife (waterfowl, racoons, gizzard shad)	Collected from Creeks and Streams within the depositoinal ranges of the HWI	None specified	N/A	N/A	N/A	N/A
74	Soil	Holoubek, I., Caslavasky, J., Vancura, R., Dusek, L., Kohoutek, J., Kocan, A., Petrik, J., Chovancova, J. P. J., and Dostal, P. 1994 Toxicological and Environmental Chemistry Project TOCOEN - the fate of selected organic pollutants in the environment. Part XXII. The contents of PAHs, PCBs, PCDDs/Fs in soil from surroundings of Brno municipal waste	The Brno municipal waste incinerator (MWI), a Project TOCOEN model source of PAHs, PCBs, PCDDs/Fs was observed and the soil contamination in its surroundings was determined. The total observed concentrations of PAHs, PCBs PCDDs/Fs were found in the ranges of 369.2 to 5,077.9 ng/g, 2.0 to 111 ng/g, and 0.018 to 0.140 pg/g TEQ, respectively	Brno, Czech Republic	Municipal Waste	1989	Cross-sectional	13	Soil samples were collected from the depth of 0-10cm	Samples were collected from areas "surrounding" the MWI. No actual locational criteria are identified	None Specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
61	Rain; Snow	Feng, X., Melander, A. P., and Klaue, B. 2000 Water, Air, & Soil Pollution Contribution of Municipal Waste Incineration to Trace Metal Deposition on the Vicinity	2 seasons (fall and winter)	Trace metals: Ba, Cu, Fe, Mn, V, Zn, Ca, Cr, Hg, As, Be, Cd, Ni, Pb	Rain: glass rain gauge and a collector Snow: PVC pipe and acid cleaned polyethelene bag	Not elaborated.	inductivly coupled plasma mass spectrometry (ICP-MS)	Basic statistical analysis (mean, s.d.), Prinicpal Component Analysis	Rain: n=8 Snow: n=19	Fall: may be the 2nd most important source for metal depositions. Winter: Incinerator is not the most important source	Analyses show that the predominant sources of metal deposition are very different for fall and winter. The most important source of metals for the rain samples collected in fall 1996 is soil dust, but for the snow samples collected in the winter 1997 is probably coal fired fly ash. The Claremont incinerator contributes less than 20% of the total variance of the elemental concentrations	Not discussed.	Low	Low	Moderate	Moderate	No
66	Soil	Floret, N., Lucot, E., Badot, P. M., Mauny, F., and Viel, J. F. 2007 Chemosphere A municipal solid waste incinerator as the single dominant point source of PCDD/Fs in an area of increased non-Hodgkin's lymphoma incidence	Not specified.	PCDD/F	Not elaborated.	Packed into glass containers and stored at room temperature.	Not specified.	Mann-Whitney U-test	75	Homogeneity of congener profiles assumed to imply MSWI as point source.	Homogeneity of congener profiles in all soil samples regardless of degree of impact or location implicates MSWI as point sources of PCDD/F congeners in soil. Concentrations in two most exposed areas significantly higher than two least exposed areas.	French Ministry of Health	Low	Low	High	Moderate	No
70	Fauna; Water	Hinzman, R. L., Adams, S. M., and Ashwood, T. L. 2096 Govt.Reports Announcements.& Index.(GRA.&I), Issue.13, %2096. Third report on the Oak Ridge K-25 Site Biological Monitoring and Abatement Program for Mitchell Branch	3 years	Hg and effluent compounds	Not specified	Not elaborated	Not stated	Basic Statistics	Not available	No, inicnerator not idenfied as the point source. Other sources of pollution are likely to be the cause (Former uranium enrichment plant)	Researchers will continue to monitoring streats withing the depositonal rages of the facility. One sampling site was eliminated from the monitoring program becaue there was an absence of contamination. Results indicate that there have been some improvements in water quality but continual monitoring is recommended.	Environmental Management Division of the Oak-Ridge K-25 site	Low	Low	Moderate	Low	No
74	Soil	Holoubek, I., Caslavasky, J., Vancura, R., Dusek, L., Kohoutek, J., Kocan, A., Petrik, J., Chovancova, J. P. J., and Dostal, P. 1994 Toxicological and Environmental Chemistry Project TOCOEN - the fate of selected organic pollutants in the environment. Part XXII. The contents of PAHs, PCBs, PCDDs/Fs in soil from surroundings of Brno municipal waste	1 year	PAHs, PCBs, PCDD/Fs	Not elaborated.	Soil samples were dried to constant weight at ambient air temperature, ground and sieved through a 18 mesh (1mm) sieve and homogenized	GC/MS	No statistical test performed	13	No correlation.	Soil contamination from industrial sources is not typical for this region and is not very problematic in comparison with other areas in CSFR	Not discussed.	Low	Low	Moderate	Low	No

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
75	Ambient Air	Hu, C. W., Chao, M. R., Wu, K. Y., Chang-Chien, G. P., Lee, W. J., Chang, L. W., and Lee, W. S. 2003 Atmospheric Environment Characterization of multiple airborne particulate metals in the surroundings of a municipal waste incinerator in Taiwan	Heavy metals are one of the concerned pollutants emitted by the municipal waste incineration system (MWIs). The objective of this study was to evaluate the potential impact on local airborne metals from the emissions of an MWI. Aerosol samples were simultaneously collected at eight different sites around the municipal waste incinerator using PS-1 sampler. The concentrations of 16 elements (Mg, Al, Fe, Cu, Zn, Pb, Ti, V, Cr, Mn, Co, Ni, As, Cd, Ba and Hg) were quantified by inductively coupled plasma-mass spectrometry (ICP-MS) and atomic absorption spectrometer (AA). The profiles of the 16 metals in the surroundings of a municipal incinerator in central Taiwan were compared with those of the emission sources. The results showed that the profiles of multiple metals obtained at all sampling sites were similar to those emitted from the MWI stack. These findings suggested that the local airborne metal pollutants might probably derive from the stack emission of the MWI. Using cadmium as an index metal, it was found that the metals like Mg, Ti, V, Cr, Mn, Co, Ni, As, and Hg are highly influenced by the stack emission from the municipal incinerator. Moreover, the ratio of other metals to Cd that were increased with the distance from the incinerator. This might be due to the additional sources contributed to airborne metals following the emission from the incinerator and a difference in particle size of each particle-bound metal.	Central Taiwan	Municipal Waste	Not specified	Cross Sectional	Ambient Air: n=8	Ambient Air	Ambient Air samples were collected from 0.9km to 3.0 kms from the MWI in the directions of NW, NE, SW, SE	None specified	N/A	N/A	N/A	N/A
77	Soil	Huang, C. W., Miyata, H., Lu, J. R., Ohta, S., Chang, T., and Kashimoto, T. 1992 Chemosphere Levels of PCBS, PCDDS and PCDFS in soil samples from incineration sites for metal reclamation in Taiwan	Surface soil samples from six sites at which waste electric wires and/or magnetic cards are incinerated for metal reclamation in taiwan. Republic of china, were analyzed for polychlorinated biphenyls (Pcbs), Polychlorinated dibenzo-p-dioxins (Pcdds) And polychlorinated dibenzofurans (Pcdfs). All samples analyzed wre contaminated with pcbs at a level of 0.45 To 77 ug/g dry weight, pcdds at n.D. To 540 ng/g and pcdfs at 1.8 To 310 ng/g. The samples from the incineration sites only with waste electric wire were heavily polluted by these chlorinated chemicals	Wan-Li, Southern Taiwan	Metal incineration sites	N/A	Cross Sectional	Soil Samples: n=6	Surface soil samples	samples collected on-site	None Specified	N/A	N/A	N/A	N/A
81	Fauna	Kashyap, R., Bhatnagar, V., Sadhu, H. G., Arora, B., Jhamb, N., and Karanjkar, R. 2008 Bull.Environ.Contam Toxicol. Residues of dioxin in egg samples collected from west zone of India	The residues of the congeners of dioxin and furan have been identified in the egg samples collected from the western zone of the India. The samples were collected from the chicken grown in sites where Municipal Corporation incinerates the municipal and hazardous wastes. All the samples showed the presence of the residues of PCDDs/Fs. The mean TEQ of dioxin and furan were 7.10 pg/g and 0.39 pg/g respectively	West India	Municipal Waste	N/A	Cross Sectional	Chicken Eggs: n=50	Chicken Eggs	Not stated (but within the vicinity of the MWI)	None specified	N/A	N/A	N/A	N/A
83	Ambient Air; Soil; Water	Kim, B. H., Lee, S. J., Mun, S. J., and Chang, Y. S. 2005 Chemosphere A case study of dioxin monitoring in and around an industrial waste incinerator in Korea	Many studies have been conducted that monitor and trace the sources of polychlorinated dibenzo-p-dioxin/furans (PCDD/Fs) by comparing congener patterns of environmental samples with those of possible sources. In this study, we measured PCDD/F concentrations and compared congener patterns of samples of various media found in and around an industrial waste incinerator in Korea, including stack gas, fly ash, bottom ash, ambient air, soil, pine needle, and human blood. We obtained reliable data on the relationship between the PCDD/F distributions in these sources and the environment, and thus found indicators with which to assess the impact of such sources on the surrounding environment. In addition, the difference between the levels of PCDD/Fs in the blood of short-term workers and long-term workers demonstrates that these workers are exposed to the compounds produced by the indicator	Korea	Industrial Waste	Not specified	Cross Sectional	Soil: n=4 Ambient Air: n=3 Water: n=1	Ambient Air, soil and water samples	Ambient Air: inside the IWI, 4kms and 5kms from the IWI Soil: inside the IWI, 0.5km, 1.3kms, 4kms from the IWI Water: surface water near the IWI	None specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
75	Ambient Air	Hu, C. W., Chao, M. R., Wu, K. Y., Chang-Chien, G. P., Lee, W. J., Chang, L. W., and Lee, W. S. 2003 Atmospheric Environment Characterization of multiple airborne particulate metals in the surroundings of a municipal waste incinerator in Taiwan	1 month	Mg, Al, Fe, Cu, Zn, Pb, Ti, V, Cr, Mn, Co, Ni, As, Cd, Ba, Hg	High volume air sampler with Teflon filters	Not elaborated.	Mg, Al, Fe, Cu, Zn, Pb, Ti, V, Cr, Mn, Co, Ni, Cd, Ba: Inductivly Coupled Mass Spectrometry Hg, As: Atomic Absorption Mass Spectrometer	Linear regression	Ambient Air: 8	Yes, profiles of ambient air are similar to the flu gas profiles.	Findings suggested that the local airborne metal pollutants might derive from the stack emission of the MWI. Using Cd as an index metal, it was found that the metals Mg, Ti, V, Cr, Mn, Co, Ni, As, and Hg are highly influenced by the stack emission from the municipal incinerator. The ratio of other metals to Cd increased with the distance from the incinerator. This might be due to the additional sources contributed to airborne metals following the	National Health Research Insitiutes, Taiwan	Low	Moderate	Moderate	Moderate	No
77	Soil	Huang, C. W., Miyata, H., Lu, J. R., Ohta, S., Chang, T., and Kashimoto, T. 1992 Chemosphere Levels of PCBS, PCDDS and PCDFS in soil samples from incineration sites for metal reclamation in Taiwan	Unspecified	PCDD/F concentrations	Not discussed	Not elaborated.	GC/MS	None stated	Soil Samples: 6	Yes	Results show that incineration for the recovery of metals from waste electric wires and magnetic cards generate substantial amounts of PCBs, PCDD/Fs	Not discussed.	Low	Low	Moderate	Low	No
81	Fauna	Kashyap, R., Bhatnagar, V., Sadhu, H. G., Arora, B., Jhamb, N., and Karanjkar, R. 2008 Bull.Environ.Contam Toxicol. Residues of dioxin in egg samples collected from west zone of India	unknown	PCDD/F concentrations	Not specified	Not elaborated.	GC/MS	None stated	Chicken Eggs: 50	Correlation of chemical levels to incinerator assumed	Dioxin content was higher than furan content. All the samples showed the presence of the residues of PCDDs/Fs. The mean TEQ of dioxin and furan were 7.10 pg/g and 0.39 pg/g respectively	Ministry of Environment and Forest, Government of India	Low	Low	Moderate	Low	No
83	Ambient Air; Soil; Water	Kim, B. H., Lee, S. J., Mun, S. J., and Chang, Y. S. 2005 Chemosphere A case study of dioxin monitoring in and around an industrial waste incinerator in Korea	unknown	PCDD/F concentrations	Ambient Air: high volume air sampler Soil: not stated Water: not stated	Not elaborated.	HRGC/HRMS	Prinicpal Component Analysis	Ambient Air: 3 Soil: 4 Water: 1	Yes, the incinerator was found to have directly influenced the observed PCDD/F congener profiles	Incinerator was found to have directly influenced the observed PCDD/F congener profiles.	Korea Science and Engineering Foundation	Low	Low	Moderate	Moderate	No

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
85	Ambient Air; Soil	Kim, K. S., Shin, S. K., Kim, K. S., Song, B. J., and Kim, J. G. 2008 Environ.Int. National monitoring of PCDD/DFs in environmental media around incinerators in Korea	To examine the levels of PCDD/DFs pollution in environmental samples in the vicinity of various incinerators, the levels of PCDD/DFs in air and soil samples collected near 17 incinerators and stack emission gases were investigated between 2003 and 2006. A total of 434 soil, 28 stack emission gas, and 38 air samples were analyzed for their PCDD/DFs concentrations. The PCDD/DFs concentrations in the flue gas samples ranged from 0.02 to 16.41 ng I-TEQ/Sm(3), with an arithmetical mean value of 3.13 ng I-TEQ/Sm(3). The PCDD/DFs concentrations in the air samples ranged from 0.032 to 0.965 pg I-TEQ/Sm(3). The soil samples contained between N.D. and 153.23 pg I-TEQ/g-dry, with an average of 7.36 pg I-TEQ/g-dry. These levels were generally consistent with or lower than many previous studies. The average PCDD/DFs levels in the soil samples decrease with increasing distance from the incinerator. From the PCDD/DFs level gradient from each plant, a distance of 500 m is suggested as being under the influence of an incinerato	Korea	Not Specified	N/A	Cross Sectional	Ambient Air: n=38 Soil: n=434	Ambient Air and Soil Samples	Ambient Air: sampling points based on atmospheric dispersion modeling Soil: 250m, 500m, 1 km, 2 km from the incinerator	None specified	N/A	N/A	N/A	N/A
87	Worker Ambient Air	Kinnes, G. M. and Bryant, C. J. 1992 Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-88.-207.-2195., 28.pages., 38.references., %1992. Health Hazard Evaluation Report No. HETA-88-207-2195, Northwest Incinerator, Philadelphia,	In response to a request from the City of Philadelphia and the American Federation of State, County and Municipal Employees, District Council 33, Local 427, an evaluation was undertaken of possible hazardous working conditions at the Northwest Incinerator (SIC-4953), Philadelphia, Pennsylvania. Full shift personal breathing zone and general area air samples were analyzed for polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), total dust, respirable dust, crystalline silica (14808607), and metals. Airborne concentrations of respirable nuisance dust were all well below the permissible exposure limits. Concentrations of PCDDss expressed as 2,3,7,8-tetrachloro-dibenzo-p-dioxin (1746016) (TCDD) equivalents ranged from 0.01 to 12.8 picograms per cubic meter. There was also significant lead (7439921) surface contamination in one wipe sample. The authors conclude that possible exposures to PCDDs/PCDFs via inhalation and from surface contamination did exist. The facility ceased operations immediately after the evaluation. The authors recommend measures to cut down on exposure should the site be reopened for use or remediation	Philadelphia, Pensylvania	Municipal Waste	1959	Cross-sectional, prospective	5 surface wipes; 6 air samples; 27 dust samples	Dust, Air	Inside the incinerator.	Expected to impacted by incinerator.	1 surface wipe; 1 air sample	Dust, Air	Air - residential yard; Surface Wipe - Hotel.	None anticipated.
88	Worker Ambient Air	Kinnes, G. M., Hanley, K. W., and Krake, A. M. 1995 Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-90.-0329.-2482., 54 pages., 64 references., %1995. Health Hazard Evaluation Report No. HETA-90-0329-2482, New York	In response to a joint request from the New York City Department of Sanitation and the American Federation of State, County, and Municipal Employees, an investigation was begun into possible exposures to polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) at three waste incineration sites of the New York City Department of Sanitation (SIC-4953), New York City, New York. Six area air samples and five bulk fly ash samples were collected. Greater amounts of PCDDss were present on the fly ash particulates collected from the electrostatic precipitator (ESP). A total of eight personal breathing zone and nine area samples were collected for metals during cleanout operations. Levels approached or exceeded the established criteria for arsenic (7440382), cadmium (7440439), lead (7439921), and nickel (7440020). For respirable dust/silica (14808607), the highest sample concentration occurred during ESP cleanout. The NIOSH recommended exposure limit for respirable quartz of 0.05mg/m3 was exceeded in one sample. The authors conclude that a health hazard existed during cleanout operations. The authors recommend that measures be taken to reduce exposures, including providing more effective respiratory protection, instruction on confined space entry, medical surveillance programs, and the prohibition of tobacco smoking in exposure locations	New York City, USA	Municipal Waste	Not specified.	Cross-Sectional, Prospective	38	Air	Inside the incinerator.	Expected to impacted by incinerator.	None collected.	N/A	N/A	N/A
103	Soil; Vegetation	Llobet, J. M., Schuhmacher, M., and Domingo, J. L. 2-4-2002 Sci.Total Environ. Spatial distribution and temporal variation of metals in the vicinity of a municipal solid waste incinerator after a modernization of the flue gas cleaning systems of the facility	In June 1994 and 1997, the concentrations of a number of elements were determined in soil and herbage samples collected in the vicinity of a municipal solid waste incinerator (MSWI) (Tarragona, Catalonia, Spain). In August 1997, an adaptation to the EU legislation on pollutant emissions from the stack was carried out to the incinerator. In June 1999, soil and herbage samples were collected again at the same sampling points and the levels of arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb), manganese (Mn), mercury (Hg), nickel (Ni) and vanadium (V) were measured by ICP-MS or AAS with graphite furnace. The results are compared with those obtained in the 1994 and 1997 surveys. In the period 1997-1999, the only significant changes in soil levels corresponded to Cd and Pb, with decreases of 21.0% and 53.5%, respectively. In vegetation, only Mn levels showed a significant reduction, which contrasts with the notable increases found in the concentrations of As, Hg and Ni. According to the results of this survey, it seems evident that other metal emission sources in the same area of study are masking the	Tarragona, Spain	Municipal Waste	1991	Longitudinal, Prospective	Soil: n-24 Herbage: n=24	Soil and Herbage	250m, 500m, 750m, 1000m, 1250m, 1500m from the stack in the 4 main wind directions (NE, NW, SE, SW)	None Specified	N/A	N/A	N/A	N/A
108	Ambient Air; Soil; Vegetation; Fauna	Lovett, A. A., Foxall, C. D., Ball, D. J., and Creaser, C. S. 1998 Journal of Hazardous Materials The Panteg monitoring project: Comparing PCB and dioxin concentrations in the vicinity of industrial facilities	This paper describes the design, implementation and outcome of a research project which investigated concentrations of PCBs and PCDD/DFs (more commonly known as dioxins and furans) in the Panteg district of Pontypool, south Wales. The project was initiated in response to public concerns regarding the operations of a chemical waste incinerator located in the area and was undertaken by a multidisciplinary team based at the University of East Anglia. Sampling was carried out around a number of industrial facilities in the Panteg district and involved a variety of environmental compartments (e.g. soil, grass, air, milk, eggs, poultry and vegetables). The results provided evidence of some unusual environmental contamination in a strip of land 200 m wide around the eastern boundary of the incineration plant. Fugitive emissions from the site appeared to be substantially responsible for this situation and exposure calculations indicated that eggs were potentially the major source of higher PCB and PCDD/DF intakes. Since the start of the project substantial alterations have been made to the incinerator and, overall, the research does seem to have resolved a number of uncertainties and helped to reduce local concerns	Pontypool, UK	Chemical Waste Incinerator	1976	Longitudinal, Retrospective	n=539	Ambient Air, Soil, Sediment, Grass, Milk, Fruit/vegetables, Poultry Feed, Eggs, Poultry Meat	Not specified	None Specified	Not particularly specified.	Ambient Air, Soil, Sediment, Grass, Milk, Fruit/vegetables, Poultry Feed, Eggs, Poultry Meat	Not specified	None Specified

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
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85	Ambient Air; Soil	Kim, K. S., Shin, S. K., Kim, K. S., Song, B. J., and Kim, J. G. 2008 Environ.Int. National monitoring of PCDD/DFs in environmental media around incinerators in Korea	3 Years	PCDD/F concentrations	Ambient Air: high volume air sampler Soil: metal hand operated sample	Not elaborated.	GC/MS	None stated	Ambient Air: 38 Soil: 434	Could not conclusively link air and soil contamination to incinerator	Results indicated that PCDD/F emissions from the incinerator directly affected the patterns of PCDD/Fs in ambient air but did not affect patterns in soil. Difficult to verify the influence of the incinerator as only 17 congeners were analyzed.	National Institute of Environmental Research (NIER), Korea	Low	Low	Moderate	Low	No
87	Worker Ambient Air	Kinnes, G. M. and Bryant, C. J. 1992 Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-88.-207.-2195., 28.pages., 38.references., %1992. Health Hazard Evaluation Report No. HETA-88-207-2195, Northwest Incinerator, Philadelphia,	1 month	PCDD/F, metals, silica, respirable dust.	Air - Microfiber filter attached to vacuum.; Surface Wipes - Hexane wetted cotton gauze pads.	Air - glass cartridge; Surface Wipes - sealed container.	GC/MS	None	N/A	PCDD/Fs found throughout facility including on lunchroom table. Only sample above NRC guideline was found in expected high exposure zone. Only high air sample was collected during furnace cleaning where employees wear PPE. No issues with respirable dust.	Potential exists for employee overexposure to both PCDD/Fs and metals via inhalation and surface contact with incinerator ash. Plant closed immediately after study. Should plant resume operations, NIOSH recommends custom designed medical surveillance program for employees.	NIOSH	Low	Moderate	High	Low	No
88	Worker Ambient Air	Kinnes, G. M., Hanley, K. W., and Krake, A. M. 1995 Hazard.Evaluations.and Technical Assistance.Branch., NIOSH., U.S.Department.of Health and Human Services, Cincinnati., Ohio., Report No.HETA.-90.-0329.-2482., 54 pages., 64 references., %1995. Health Hazard Evaluation Report No. HETA-90-0329-2482, New York	2 years	PCDD/F, As, Cd, Pb, Ni, respirable dust	Microfibre filter attached to vacuum pump.	Filters	GC/MS - PCDD/F; IPC/MS - Metals.	None	N/A	4 of 6 area air samples exceeded NRC guideline for PCDD/F, one sample by factor of 80. Airborne metal concentrations during some cleaning periods exceeded protection capabilities for respirators worn.	Health hazard exists for workers involved in cleanout operations at the incinerators. Worker exposure can be reduced through the proper use of engineering controls and work practices.	NIOSH	Low	Moderate	High	Low	No
103	Soil; Vegetation	Llobet, J. M., Schuhmacher, M., and Domingo, J. L. 2-4-2002 Sci.Total Environ. Spatial distribution and temporal variation of metals in the vicinity of a municipal solid waste incinerator after a modernization of the flue gas cleaning systems of the facility	6 years	Metals: (As, Cd, Cr, Hg, Mn, Ni, Pb, V)	Soil: samples taken from the upper 3cm of soil and scrapped into polyethelene sampling bags Herbage: samples were cut at a height of approx 4cm from the soil and immediately	Soil: not elaborated Herbage: dried at room temperature, kept in double aluminum foil and packed in labeled plastic bags and stored at room temperature until analysis	Soils: As, Cd, Cr, Hg, Mn, Pb, V: inductively coupled plasma spectrometry Ni: atomic absorption spectrometry Herbage:	ANOVA, Kruskal-Wallis test, students t-test	Soil: 24 Herbage: 24	Contamination not conclusively linked to the MWI	Soil: the only significant changes corresponded to the decreases in Cd and Pb Herbage: As, Hg and Ni showed significant increases Authors conclude that it is evident that other metal emission sources in the same area of study are masking the environmental improvements carried out in the MWI.	SIRUSA	Low	Low	Moderate	Moderate	No
108	Ambient Air; Soil; Vegetation; Fauna	Lovett, A. A., Foxall, C. D., Ball, D. J., and Creaser, C. S. 1998 Journal of Hazardous Materials The Panteg monitoring project: Comparing PCB and dioxin concentrations in the vicinity of industrial facilities	4 years	PCB, PCDD/F concentrations	Not discussed	Not elaborated.	GC/MS	None stated	Samples: 536	Yes, but fugitive emissions seem to be causing contamination, not stack emissions	Fugitive emissions from the site appeared to be substantially responsible for this situation and exposure calculations indicated that eggs were potentially the major source of higher PCB and PCDD/DF intakes. Since the start of the project substantial alterations have been made to the incinerator and, overall, the research does seem to have resolved a number of uncertainties and helped to reduce local concerns	Welsh Office, UK	Moderate	Moderate	Low	Low	No

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
112	Ambient Air	Mari, M., Schuhmacher, M., Feliubadalo, J., and Domingo, J. L. 2008 Chemosphere Air concentrations of PCDD/Fs, PCBs and PCNs using active and passive air samplers	The concentrations of polychlorinated dibenzo-p-dioxins and furans (PCDD/Fs), polychlorinated biphenyls (PCBs) and polychlorinated naphthalenes (PCNs) were determined in air samples collected at four sampling sites located in two zones of Barcelona (Spain): near a municipal solid waste incinerator (MSWI) and a combined cycle power plant (3 sites), and at a background/control site. Samples were collected using high-volume active samplers. Moreover, 4 PUF passive samplers were deployed at the same sampling points during three months. For PCDD/Fs, total WHO-TEQ values were 27.3 and 10.9 fg WHO-TEQm(-3) at the urban/industrial and the background sites, respectively. The sum of 7 PCB congeners and the Sigma PCN levels were also higher at the industrial site than at the background site. In order to compare active and passive sampling, the accumulated amounts of PCDD/Fs, PCBs and PCNs in the four passive air samplers, as well as the total toxic equivalents in each sampling site were also determined. To assess the use of PUF passive samplers as a complementary tool for PCDD/F, PCB and PCN monitoring, sampling rates were calculated in accordance with the theory of passive air samplers. PUF disks allowed establishing differences among zones for the POP levels, showing that they can be a suitable method to determine POP concentrations in air in areas with various potential emission sources. Although both particle and gas phase were sorbed by the PUFs, data of gas phase congeners are more reproducible	San Adria del Besos, Barcelona, Spain	Municipal Waste	Not specified	Longitudinal, Prospective	Not particularly specified	Ambient air samples	3 samples were in the vicinity of a MWI and a combined cycle power plant	None Specified	Not particularly specified.	Ambient air samples	semi rural area close to a large park with no direct pollutant sources	No
116	Vegetation; Fauna	Marti-Cid, R., Bocio, A., and Domingo, J. L. 2008 Chemosphere Dietary exposure to PCDD/PCDFs by individuals living near a hazardous waste incinerator in Catalonia, Spain: temporal trend	The levels of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) were measured in foodstuffs randomly acquired in July 2006 in various locations of Tarragona County (Catalonia, Spain), which are near a hazardous waste incinerator (HWI). A total of 35 composite samples, belonging to various food groups (vegetables, pulses, cereals, fruits, fish and seafood, meat and meat products, eggs, milk, dairy products, and oils and fats) were analyzed by HRGC/HRMS. The dietary intake of PCDD/PCDFs was subsequently determined and compared with a previous survey performed in 2002. For calculations, recent data on consumption of the selected food items were used. Total dietary intake of PCDD/PCDFs for the general population of Tarragona County was estimated to be 27.81 pg WHO-TEQ/day, value notably lower than that found in the 2002 study, 63.80 pg WHO-TEQ/day. Fish and seafood (28%), oils and fats (22%), eggs (17%), and dairy products (11%) were the most important contributors to this intake, while pulses (1%), milk (2%), vegetables (3%) and fruits (3%) showed the lowest contribution to total WHO-TEQ. The current PCDD/PCDF intake is also considerably lower than the intake estimated in 1998 for the population of the same geographical area, 210.1 pg I-TEQ/day, when a baseline study was carried out during the construction of the HWI. The present intake is also compared with the dietary intakes of PCDD/PCDFs recently (2006-2007) reported for a number of regions and countries	Tarragona, Spain	Hazardous Waste	1999	Longitudinal, Prospective	35 Composites	Meat, fish and seafood, pulses, cereal, vegetables, tubers, fruits, whole milk, dairy products, eggs and sugar.	In the same county as the incinerator.	None identified.	Baseline and 3 years after survey completed in prior study.	Meat, fish and seafood, pulses, cereal, vegetables, tubers, fruits, whole milk, dairy products, eggs and sugar.	In the same county as the incinerator.	No
118	Soil; Vegetation	Meneses, M., Llobet, J. M., Granero, S., Schuhmacher, M., and Domingo, J. L. 2-9-1999 Sci.Total Environ. Monitoring metals in the vicinity of a municipal waste incinerator: temporal variation in soils and vegetation	The aim of this study was to determine the temporal variation in the concentrations of arsenic (As), beryllium (Be), cadmium (Cd), chromium (Cr), manganese (Mn), mercury (Hg), nickel (Ni), lead (Pb), tin (Sn), thallium (Tl), vanadium (V) and zinc (Zn) in soil and vegetation near an old municipal solid waste incinerator (MSWI). In October 1997, 24 soil and 24 herbage samples were collected at the same sampling points in which samples were also taken in October 1996. With the exception of an increase in the levels of Be and Ni, no significant differences in soils between both surveys were found; only Cr and V (decreases) and Hg (increase) showed significant variations in herbage samples during the last year. The concentrations of most elements in soil and vegetation samples collected near the MSWI are within the ranges previously reported for soil and vegetation in the vicinity of MSWIs	Montcada, Spain	Municipal Waste	1975	Longitudinal, Prospective	Soil: n-24 Herbage: n=24	Soil and Herbage	100, 250, 500, 750, 1000, 1500, 2000, 3000 meters from the stack in the 3 main wind directions S, NE, NW	None Specified	See Ref ID 135 for baseline data	N/A	N/A	N/A
119	Ambient Air	Mi, Hsiao Hsuan, Chiang, Chow Feng, Lai, Ching Cheng, Wang, Lin Chi, and Yang, Hsi Hsien 2001 Aerosol and Air Quality Resarch Comparison of PAH Emission from a Municipal Waste Incinerator and Mobile Sources	PAH emissions from a municipal waste incinerator stack in central Taiwan were sampled and analyzed by gas phase and particulate phase samples. A modified Gaussian atmospheric dispersion model, industrial sources complex (ISCST3), was used to simulate the PAH concentration in ambient air, which was compared with the measured PAH concentration in the ambient air. Total-PAH emission factor for the municipal waste incinerator ranged between 748 and 992 mg/ton-waste and averaged 871 mg/ton-waste, while the total-PAH emission rate ranged between 21,000 and 27,900 mg/hr and averaged 24,500 mg/hr. The results of dispersion modeling indicated that the contribution of PAHs to the ambient air by the municipal waste incinerator only reached 0.98% of the background concentration. Consequently, other emission sources, especially mobile sources, impact air quality more significantly	Central Taiwan	Municipal Waste	N/A	Longitudinal, Prospective	Ambient Air: n=39	Ambient Air samples	4 locations within 5.5 kms surrounding the MWI	None Specified	N/A	N/A	N/A	N/A
122	Soil; Vegetation	Morselli, L., Bartoli, M., Brusori, B., and Passarini, F. 4-22-2002 Sci.Total Environ. Application of an integrated environmental monitoring system to an incineration plant	An integrated environmental monitoring system is an innovative approach which allows remarkable understanding of impacts due to a contamination source. Here we report results from environmental monitoring near a typical Italian incinerator plant. By means of mathematical dispersion models, zones of maximum pollutant depositions were determined; according to these simulations, a defined monitoring network was established. Heavy metals, chosen as environmental indicators, showed a wide flux range in gas emissions from the incinerator, over different sampling years. In particular, emissions in the year 2000 were marked by high Pb and Cd concentrations. Correspondingly, soil samples also exhibited a greater concentration of the same metals in 2000, than in previous years. Principal component analysis allowed a better visualisation of these similarities, also showing an interesting correlation between heavy metals observed both in gas emissions and in soil samples. Soil distant from the incinerator was found to be less affected by heavy metal contamination. Also atmospheric wet and dry depositions indicated a significant dependence on distance from incinerator, though extremely variable metal fluxes were registered during different months. Finally, vegetation samples, seasonal or evergreen, did not provide evidence of a significant heavy metal enrichment, apart from an apparent dependence on contamination source distance	Rimini, Italy	Municipal Waste	N/A	Longitudinal, Prospective	Soil: n= 12 Vegetation: n= 12	Surface soil and 2 types of venation (evergreen, and seasonal, edible)	Samples were collected in areas of different depositional concentrations. No actual distance from the incinerator are given	None Specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
112	Ambient Air	Mari, M., Schuhmacher, M., Feliubadalo, J., and Domingo, J. L. 2008 Chemosphere Air concentrations of PCDD/Fs, PCBs and PCNs using active and passive air samplers	4 months	PCDD/Fs, PCBs, PCNs	high volume air samplers; passive air samples	Not elaborated.	HRGC/HRMS	None stated	Not stated	Not specified if chemical agents were directly correlated to incinerator or combined cycle power plant	Levels for most chemical agents were higher in urban/industrial sampling sites when compared to the rural sampling site. Active air samplers and passive air samplers should be used as complimentary tools in environmental air monitoring	Metropolitan Entity of the Environment, Barcelona, Catalonia, Spain	Moderate	Moderate	Moderate	Low	No
116	Vegetation; Fauna	Marti-Cid, R., Bocio, A., and Domingo, J. L. 2008 Chemosphere Dietary exposure to PCDD/PCDFs by individuals living near a hazardous waste incinerator in Catalonia, Spain: temporal trend	8 years	PCDD/F	Not elaborated.	Not elaborated.	GC/MS	None	N/A	None identified.	With the exception of pulses and eggs, there were decreases across the board in WHO-TEQ values for PCDD/Fs in foodstuffs between 2002 and 2006.	Agencia de Residus, Catalonia, Spain	High	Moderate	High	Low	No
118	Soil; Vegetation	Meneses, M., Llobet, J. M., Granero, S., Schuhmacher, M., and Domingo, J. L. 2-9-1999 Sci.Total Environ. Monitoring metals in the vicinity of a municipal waste incinerator: temporal variation in soils and vegetation	1 year	As, Be, Cd, Cr, Hg, Mn, Ni, Pb, Sn, Tl, V	Soil: polyethylene sampling bags Herbage: packed in aluminum foils	Soil: dried at 30 C until constant weight and sieved to pass through a 2mm mesh screen Herbage: dried at room temperature, kept in a double aluminum foil and packed in labeled plastic bags	Soil and Herbage samples were analysed by inductively coupled mass spectrometry	Kruskal-Wallis test, Students t-test	Soil: n=24 Herbage: n=24	Levels of metals could not conclusively be linked to the MWI	Metal concentrations in soils remained basically unchanged from the baseline Significant differences in vegetation were only found for Cr and V (decrease) and Hg (Increase). These differences could be explained by taking into account factors that can affect metal emission from the plant, potential changes in the	Entitat Metropolitana del Medi Ambient, Barcelona Spain	Low	Low	Moderate	Moderate	No
119	Ambient Air	Mi, Hsiao Hsuan, Chiang, Chow Feng, Lai, Ching Cheng, Wang, Lin Chi, and Yang, Hsi Hsien 2001 Aerosol and Air Quality Resarch Comparison of PAH Emission from a Municipal Waste Incinerator and Mobile Sources	7 months	PAH concentrations	PS-1 sampler	Not elaborated.	GC/MS	None stated	Ambient air: 39	Effect of the incinerator on PAHs levels was considered insignificant	The air quality at the 4 ambient air sampling sites was affected by environmental conditions, especially for the indicator pollutants (such as IND, DBA, BghiP, and BdF) of traffic pollution sources. Stack flue gas from the incinerator has a minor effect on the four sampling sites. The single stationary pollution source (incinerator) thus has a relatively minor effect on its immediate environment less than that of traffic sources. The overall effect of the incinerator on ambient air quality is this insignificant.	National Science Council of the Republic of China	Low	Low	Moderate	Low	No
122	Soil; Vegetation	Morselli, L., Bartoli, M., Brusori, B., and Passarini, F. 4-22-2002 Sci.Total Environ. Application of an integrated environmental monitoring system to an incineration plant	3 years	Heavy metals (Cd, Cr, Cu, Hg, Mn, Ni, Pb, Zn)	Samples were collected and put in polyethylene sampling bags	Not elaborated.	Determination of Cd, Cr, Cu, Mn, Ni, Pb and Zn was determined by GFAAS or ICP-AES Hg was determined by FIAS-AAS	Basic Statistical Analysis	Soil: n= 12 Vegetation: n= 12	Yes, there was a correlation between concentrations and distance from the incinerator	Soil samples displayed correlations between heavy metals, a dependence on the distance from the plant and a temporal trend in agreement with that found in stack gas emissions. Vegetation samples showed very low heavy metals concentration, but like all the other media, displayed a clear dependence on the distance from the incinerator. Other sources of pollution (traffic in particular) are also sources of deposition.	AMIA s.p.a. (Rimini) and University of Bologna, Department of Industrial Chemistry	Low	Low	Moderate	Moderate	No

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
123	Ambient Air; Soil; Vegetation	Morselli, L., Passarini, F., Zamagni, E., and Brusori, B. 2000 Ann.Chim. Methodological approach for an integrated environmental monitoring system relative to heavy metals from an incineration plant	The use of an Integrated Environmental Monitoring System is an innovative and very important approach for the determination of environmental impacts due to a contamination source. In the present work, the methodological approach is described and applied to the case study of a MSW incineration plant. Heavy metals were chosen as Environmental Indicators. Gaseous emissions were measured and correlated to wet and dry depositions, soil and vegetation samples. Results show a good correlation between stack emissions and atmospheric depositions; less with soil and vegetation, but these results are important in order to design a standard procedure for an Integrated Monitoring System	Rimini, Italy	Municipal Waste	Unspecified	Cross-sectional, prospective sampling	Not particularly specified	Air, Soil, Vegetation	Air samples were selected based on atmospheric modelling at two sites - a maxmimum predicted deposition site and a lower predicted deposition site. No information is given on locations of	None identified.	Not particularly specified.	Air, Soil, Vegetation	Air samples were selected based on atmospheric modelling at two sites - a maxmimum predicted deposition site and a lower predicted deposition site. No information is given on	Not elucidated.
124	Soil; Vegetation	Morselli, L., Passarini, F., and Bartoli, M. 2002 Waste Manag. The environmental fate of heavy metals arising from a MSW incineration plant	Pollutant fluxes from municipal solid waste (MSW) incinerators are of a certain concern, especially gaseous emissions from the stack, which constitute the major effluent from the plant. In this work, heavy metals in soil and vegetation sampled in different sites around the plant are compared with those found in the gaseous emissions from an incinerator: the suspected source and environmental matrices are observed together, in order to detect a possible relationship of cause and effect, using statistical methods. The incinerator examined, regarding dimension and technology, can be considered a typical Italian one. Heavy metal concentrations in soil and vegetation show a clear dependence on sampling year; similar behaviour can be found in emission fluxes referring to the same years. A dependence on the distance from the incinerator is also apparent. This study supplies a methodological approach that can be easily extended and applied to other suspected contamination sources	Italy	Municipal Waste	N/A	Longitudinal, Prospective	Soil: n=45 (15 samples/year x 3 years) Vegetation: n=45 (15 samples/year x 3 years)	Soil and Vegetation (evergreen and seasonal edible vegetation)	Not specified	None Specified	N/A	N/A	N/A	N/A
131	Ambient Air	Nishikawa, H., Katami, T., and Yasuhara, A. 1993 Chemosphere Contribution of an industrial waste incinerator to the atmospheric concentrations of volatile chlorinated organic compounds	The contribution of five volatile chlorinated organic compounds emitted from waste incinerator to the surrounding atmosphere were investigated. The atmospheric concentrations of these compounds were low level as compared with those around the factories in which chlorinated organic compounds were used as solvent. It was found that the influence of the incinerator exhausts to the atmosphere was negligible or very small for these compounds	Japan	Industrial Waste	N/A	Cross sectional	Ambient Air: n=7	Ambient Air	250m S, 500m S, 250m SW, 500m SW, 250m NW, 500m NW, 500m E.	None Specified	N/A	N/A	N/A	N/A
133	Ambient Air	Oh, J. E., Chang, Y. S., and Ikonomou, M. G. 2002 J.Air Waste Manag.Assoc. Levels and characteristic homologue patterns of polychlorinated dibenzo-p-dioxins and dibenzofurans in various incinerator emissions and in air collected near an incinerator	Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) were monitored in stack gas and fly ash of various Korean incinerators and in air samples collected near the facilities. Concentrations of PCDD/Fs in emissions were investigated, and characteristic PCDD/F homologue patterns were classified using statistical analyses. The PCDD/F emission levels in stack gas and fly ash samples from small incinerators (SIs) were higher than those from municipal solid waste incinerators (MSWIs). The PCDD/F concentrations ranged between 0.38 and 1.16 pg I-TEQ/m3 (21.2-75.2 pg/m3) in ambient air samples. The lower-chlorinated furans were the dominant components in most of the stack gas and fly ash samples from SIs, although this was not the case for fly ash from MSWIs. This homologue pattern is consistent with other studies reporting a high fraction of lower-chlorinated furans in most environmental samples affected by incinerator emissions, and it can be used as an indicator to assess the impact of such facilities on the surrounding environment	Korea	Municipal Waste	N/A	Longitudinal, Prospective	Ambient air: n=8	Ambient Air samples	Site was an urban city within 300 meters from a MWI	None Specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
123	Ambient Air; Soil; Vegetation	Morselli, L., Passarini, F., Zamagni, E., and Brusori, B. 2000 Ann.Chim. Methodological approach for an integrated environmental monitoring system relative to heavy metals from an incineration plant	1-2 years	Pb, Cd, Ni, Cr, Cu, Zn, Hg, Mn	Air - ARS 1010 Deposition on Aquatic Surface Sampler; Soil, Veg. - Detailed in previous study.	Air - Low-density polyethylene bottles. Soil - Polyethylene bags. Vegetation - Unspecified.	FAAS	Dissimilarity Matrix based on Euclidian Distance	N/A	Author found some similarity between emissions and air deposition concentrations. No observable correlation in soil and vegetation samples.	Atmospheric depositions are an accurate measure of environmental contamination by incineration. Integrated environmental monitoring systems have value if done properly.	Not discussed.	Low	Low	Low	Moderate	No
124	Soil; Vegetation	Morselli, L., Passarini, F., and Bartoli, M. 2002 Waste Manag. The environmental fate of heavy metals arising from a MSW incineration plant	2 years	Heavy metals (Cd, Cr, Cu, Hg, Mn, Ni, Pb, Zn)	Not elaborated.	Soil: Heavy metal concentration was determined after a complete digestion of soil samples Vegetation: heavy metal content was performed using concentrated HNO_3 and H_2O_2 in a microwave oven	Not stated	Prinicpal Component Analysis	Soil: 45 Vegetation: 45	Metal levels in soil and vegetation samples reflect emissions from the incinerator stack	Heavy metal concentration trends in soil and vegetation reflect the behavior of their fluxes from incinerator stack, during the examined years.	Not discussed.	Low	Low	Moderate	Low	No
131	Ambient Air	Nishikawa, H., Katami, T., and Yasuhara, A. 1993 Chemosphere Contribution of an industrial waste incinerator to the atmospheric concentrations of volatile chlorinated organic compounds	2 days	VOCs (Chloroform, 1,1,1 -TCE, CCl_4, TCE, PCE)	300ml gas sampling bottle	N/A	Gas chromatograph with an electron capture detector (ECD)	None stated	Ambient Air: 7	Influence of the incinerator emission to the surrounding atmosphere is negligible or very small for VOCs	Influence of the incinerator emission to the surrounding atmosphere is negligible or very small for VOCs. The reason for higher concentration levels at leeward sites than those windward sites was assumed that some waste solvent kept in drums for burning at the incinerator plant vaporized to the atmosphere. The influence of the whole incineration plant to the surrounding atmospheric environment for these compounds was small	Not discussed.	Low	Low	Moderate	Low	No
133	Ambient Air	Oh, J. E., Chang, Y. S., and Ikonomou, M. G. 2002 J.Air Waste Manag.Assoc. Levels and characteristic homologue patterns of polychlorinated dibenzo-p-dioxins and dibenzofurans in various incinerator emissions and in air collected near an incinerator	15 months	PCDD/F concentrations	High volume air sampler	Not elaborated.	HRGC/HRMS	multivariate analysis, Principal component analysis	Ambient Air: 8	Correlations in the homologue patterns between the MWI stack gas and ambient air suggest that the PCDD/F levels in the ambient air are influenced by the MWI	The homologue patterns in the stack gas and ambient air were similar. This suggests that the ambient air surrounding the MWI is influenced by the MWI emissions. More research is needed to identify other possible sources of ambient air contamination in the area.	National Institute of Environmental Research (NIER), Korea Science and Engineering Foundation	Low	Low	Moderate	Low	No

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
135	Soil	Ohta, S., Kuriyama, S., Aozasa, O., Nakao, T., Tanahashi, M., and Miyata, H. 2000 Bull.Environ.Contam Toxicol. Survey on levels of PCDDs, PCDFs, and non-ortho Co-PCBs in soil and sediment from a high cancer area near a batch-type municipal solid waste incinerator in Japan	N/A	Shintone Village, Japan	Municipal Waste	1971	Cross sectional	Soil: n=52 Surface Sediment: n=5	Soil Samples (depth 2-3cms) Surface Sediment Samples	Soil Samples collected from 6 radial points at distances of 200m, 500m, 800m, 1000m, 1200m, 1400m, 1600m, 1800m, 2000m. Surface Sediment Samples were collected at 5 points (narrow	None Specified	N/A	N/A	N/A	N/A
140	Ambient Air	Pilspanen, W. H., Czuczwa, J. M., and Sobeih, I. M. 1992 Environmental Science and Technology Work area air monitoring for chlorinated dioxins and furans at a municipal waste power boiler facility	N/A	Ohio, USA	Municipal Waste	N/A	Longitudinal	Ambient Air: unspecified	Ambient Air within the incineration facility	upper boiler, precipitator room, operating floor, ash handling, shredder room	None Specified	N/A	N/A	N/A	N/A
159	Soil; Vegetation	Schuhmacher, M., Granero, S., Rivera, J., Muller, L., Llobet, J. M., and Domingo, J. L. 2000 Chemosphere Atmospheric deposition of PCDD/Fs near an old municipal solid waste incinerator: levels in soil and vegetation	The levels of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) were determined in soil and vegetation samples taken from 24 sites in the vicinity of an old municipal solid waste incinerator (San Adria del Besos, Barcelona, Spain). Duplicate samples were collected within a radius of 3 km from the stack. PCDD/F concentrations in soils ranged from 1.22 to 34.28 ng I-TEQ/kg (d.m.) with median and mean values of 9.06 and 12.24 ng I-TEQ/kg, respectively. In turn, the levels of PCDD/Fs in vegetation samples ranged from 0.33 to 1.98 ng I-TEQ/kg (d.m.), with median and mean values of 0.58 and 0.70 ng I-TEQ/kg, respectively. Although the present PCDD/F concentrations in soil samples were higher than those recently found in soils taken near other incinerators from Catalonia, they are of the same order of magnitude than the levels of these pollutants found in incinerators from other countries. By contrast, the concentrations of PCDD/Fs in herbage samples were comparable to those found in recent surveys carried out in Catalonia	San Adria del Besos, Barcelona, Spain	Municipal Waste	1975	Cross-sectional, prospective sampling	Soil: n=24 Herbage: n=24	Soil and Herbage	250m=6 samples 500m= 5 samples 750m= 4 samples 1000m= 3 samples 1500m= 3 samples 3000m= 3 samples	None Specified	N/A	N/A	N/A	N/A
167	Soil; Vegetation	Schuhmacher, M. and Domingo, J. L. 2006 Environ.Int. Long-term study of environmental levels of dioxins and furans in the vicinity of a municipal solid waste incinerator	From 1975 to 2004, a municipal solid waste incinerator (MSWI) was operating in Montcada (Barcelona, Catalonia, Spain). Because of the potential health risks derived from emission of pollutants by the facility, especially polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs), a long-term monitoring program focused on measuring the environmental levels of PCDD/Fs near the facility, and to assess the health risks for the population living in the neighborhood, was established between 1996 and 2002. A total number of 111 soil and 121 herbage samples were analyzed for PCDD/Fs during this period. Human health risks for the individuals living near the MSWI (500 and 1,000 m) were also assessed before (1998) and after modernization (2000) of the facility. It included PCDD/F inhalation, dermal contact, soil and dust ingestion, and food intake. All these data are here summarized. The environmental levels of PCDD/Fs showed that the MSWI was not the main responsible of the atmospheric pollution by these compounds. In turn, human health risks for the population living in the vicinity of the facility after introduction of a modern technology were negligible in comparison with the dietary PCDD/F exposure	Montcada, Spain	Municipal Waste	1975	Longitudinal, Prospective	Soil: n=111 Herbage: n=121 (From 1996-2002)	Soil and Herbage	100, 250, 500, 750, 1000, 1500, 2000, 3000 meters from the stack in the 3 main wind directions S, NE, NW	None Specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
135	Soil	Ohta, S., Kuriyama, S., Aozasa, O., Nakao, T., Tanahashi, M., and Miyata, H. 2000 Bull.Environ.Contam Toxicol. Survey on levels of PCDDs, PCDFs, and non-ortho Co-PCBs in soil and sediment from a high cancer area near a batch-type municipal solid waste incinerator in Japan	1 month	PCDD/F concentrations	Not elaborated.	Not elaborated.	GC/MS	Basic Statistical Analysis	Soil: 52 Sediment: 5	Chemical levels were assumed to be correlated to the MWI. No alternative sources explored	Residents upwind to the MWI had higher health status. Difficult to conclude a relationship between high cancer death rate and the pollution level by dioxin analogues in the area.	Grant-in-Aid for Scientific Research	Low	Low	Moderate	Low	No
140	Ambient Air	Pilspanen, W. H., Czuczwa, J. M., and Sobeih, I. M. 1992 Environmental Science and Technology Work area air monitoring for chlorinated dioxins and furans at a municipal waste power boiler facility	6 months	PCDD/F concentrations	high volume air sampler with a quartz fiber filter followed by a polyurethane foam plug	Not elaborated.	HRGC/HRMS	None stated	Ambient Air: unsure	Yes, source of emission are likely associated with the ambient particulate emitted from the combustion back-pressure or leakage from the boiler.	TCDF and PeCDD are the predominant isomer groups found in the work areas. Sources of emissions are likely associated with the ambient particulate emitted from the combustion back-pressure or leakage from the boiler and t his material is carried by thermal ventilation currents throughout the plant. The shredder room exhibited an isomer profile similar to the Ohio ambient air but with a higher concentration of the plant-wide isomers especially	Not discussed.	Low	Low	Moderate	Low	No
159	Soil; Vegetation	Schuhmacher, M., Granero, S., Rivera, J., Muller, L., Llobet, J. M., and Domingo, J. L. 2000 Chemosphere Atmospheric deposition of PCDD/Fs near an old municipal solid waste incinerator: levels in soil and vegetation	N/A	PCDD/PCDF Concentrations	Soil: N/A Herbage: cut approx 4cm from the soil and packed in aluminum foils	samples were dried at room temperature, and kept until analysis	GC/MS	Sceffe test, multivariate analysis, principal component analysis	Soil: 24 Herbage: 24	Soil: soil contamination may be caused by other sources than MWI Herbage: yes, herbage contamination is likely the result of the MWI	concentrations of PCDD/F was higher in soils than in herbage. Levels found were in the same order of magnitude as those reported in other studies.	Not discussed.	Low	Low	Moderate	Moderate	No
167	Soil; Vegetation	Schuhmacher, M. and Domingo, J. L. 2006 Environ.Int. Long-term study of environmental levels of dioxins and furans in the vicinity of a municipal solid waste incinerator	6 years	PCDD/F concentrations	Soil: N/A Herbage: cut approx 4cm from the soil and packed in aluminum foils	Soil: sieved through a 2mm mesh screen to achieve homogenous grain distribution and dried overnight at 130 C Herbage: not presented	HRGC/HRMS	Kruskal-Wallis test, multivariate analysis, Principal component analysis	Soil: 111 Herbage: 121	Yes. Levels correlated to MWI, but it was not the main/only source of PCDD/F emissions	Although levels of PCDD/F in herbage declined, it was not especially remarkable after the introduction of a new clean air device, this indicates that the MWI was not the principal source of PCDD/F emissions. Levels in soils were higher for this MWI than newer modern MWIs but they are in the same range if not lower than levels reported in similar studies	Metropolitan Entity of the Environment, Barcelona, Catalonia, Spain	Low	Low	Moderate	Moderate	No

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
171	Soil	Schuhmacher, M., Xifro, A., Llobet, J. M., de Kok, H. A., and Domingo, J. L. 1997 Arch.Environ.Contam Toxicol. PCDD/Fs in soil samples collected in the vicinity of a municipal solid waste incinerator: human health risks	The concentrations of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) were determined in soil samples taken from 24 sites in the vicinity of a municipal solid waste incinerator (Montcada, Barcelona, Spain). Samples were collected within a radius of 3 km in each of the three main directions of the wind rose in that area. Hepta- and octa-CDDs were the predominant congeners and contributors to TEQ. PCDD/F levels ranged from 0.30 to 44.26 ng TEQ/kg (dry matter), with median and mean values of 3.52 and 6.91 ng TEQ/kg, respectively. The highest and lowest PCDD/F concentrations were found at 750 m (44.26 ng TEQ/kg) and 3000 m (0. 30 ng TEQ/kg) from the stack, while the PCDD/PCDF ratio was 1.78. The health risk analysis of the data shows that the PCDD/F intake from soils is substantially lower than the tolerable daily intake for toxicologic (other than cancer) effects of PCDD/Fs	Montcada, Spain	Municipal Waste	1975	Cross-sectional, prospective sampling	Soil: n=24	soil	100, 250, 500, 750, 1000, 1500, 2000, 3000 meters from the stack in the 3 main wind directions S, NE, NW	None Specified	N/A	N/A	N/A	N/A
172	Vegetation	Schuhmacher, M., Domingo, J. L., Xifro, A., Granero, S., Llobet, J. M., and De Kok, H. A. M. 1998 Journal of Environmental Science and Health - Part A Toxic/Hazardous Substances and Environmental Engineering Presence of dioxins and furans in vegetation samples collected in the neighbourhood of a municipal solid waste	Polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) were analyzed by GC/MS in 24 vegetation samples collected in the vicinity of a municipal solid waste incinerator. Samples were taken within a radius of 3000 m from the stack in each of the three main wind directions in that area. Total TEq levels for PCDD/Fs ranged between 1.07 ng/kg (dry matter) and 3.05 ng/kg (dry matter), with median and mean values of 1.88 y 1.92 ng/kg (dry matter), respectively. OCDD/F and 1,2,3,4,6,7,8-HpCDD/F were the dominating dioxin and furan congeners found in vegetation samples. Although the highest PCDD/F level (3.05 ng TEq/kg) was found at the north-west (1000 m from the stack) direction, for most congeners and contributors to Teq the highest concentrations were observed at distances less than 250 m from the facility. The present results should be of concern for future assessments on the correlation between decreases in the atmospheric PCDD/F emission from the incinerator and the decline in the levels of PCDD/Fs in vegetation	Montcada, Spain	Municipal Waste	1975	Cross-sectional, prospective sampling	Vegetation: n=24	vegetation samples (*boutelova gracilis)* 12 0-150g (dry weight). Vegetation was cut approx 4cm from the soil	100, 250, 500, 750, 1000, 1500, 2000, 3000 meters from the stack in the 3 main wind directions S, NE, NW	None Specified	N/A	N/A	N/A	N/A
173	Soil	Schuhmacher, M., Domingo, J. L., Granero, S., Llobet, J. M., Eljarrat, E., and Rivera, J. 1999 Chemosphere Soil monitoring in the vicinity of a municipal solid waste incinerator: Temporal variation of PCDD/Fs	To determine the temporal variation in the levels of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) in soils in the vicinity of a municipal solid waste incinerator (MSWI), 24 soil samples were collected at the same points in which samples had been taken one year before. In the previous survey, PCDD/F concentrations ranged from 0.22 to 5.80 ng I-TEQ/kg (dry matter) with median and mean values of 0.80 and 1.08 ng I-TEQ/kg (dry matter), respectively. In the present survey, PCDD/F levels ranged from 0.11 to 3.88 ng I-TEQ/kg (dry matter) with a median value of 0.88 ng I-TEQ/kg (dry matter) and a mean value of 1.17 ng I-TEQ/kg (dry matter). It means an increase of 8.3% in the mean PCDD/F levels during the last year. In turn, the mean PCDD/PCDF ratios were 0.62 (previous survey) and 0.55 (current survey), respectively. A comparison of the increases in the quantities of PCDD/Fs found in soils with those estimated according calculations suggests that no remarkable sources of PCDD/F emissions other than the MSWI are present in the area here examined. The differences between the current results and those found in 1996 could be explained by the heterogeneity of the samples	Tarragona, Spain	Municipal Waste	1991	Longitudinal, Prospective	Soil: n=24	Soil samples	250m 500m 750m 1000m 1250m 1500m from the stack	None Specified	N/A	N/A	N/A	N/A
174	Vegetation	Schuhmacher, M., Domingo, J. L., Llobet, J. M., Sunderhauf, W., and Muller, L. 7-30-1998 Sci.Total Environ. Temporal variation of PCDD/F concentrations in vegetation samples collected in the vicinity of a municipal waste incinerator (1996-1997)	In 1996, the concentrations of polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) were determined by HRGC/HRMS in 24 vegetation samples collected in the vicinity of a municipal solid waste incinerator (Tarragona, Catalonia, Spain). In the present study 24 vegetation samples were again taken at the same sampling points and analyzed for the levels of PCDD/Fs. The results were compared with those obtained in the previous survey. While in the 1996 study, PCDD/F levels ranged from 0.15 to 62.09 ng I-TEQ/kg (dry matter) (median value, 0.33 ng I-TEQ/kg; mean value, 4.11 ng I-TEQ/kg), the concentrations of PCDD/Fs in the 1997 survey ranged between 0.11 and 0.50 ng I-TEQ/kg (dry matter) (median value, 0.20 ng I-TEQ/kg; mean value, 0.23 ng I-TEQ/kg). The individual comparison between PCDD/F levels in the samples collected in 1996 and 1997 showed a decrease in 15 of the 24 sampling points. When the comparison was carried out in relation to each of the four main wind directions in the area, the highest decrease in PCDD/F concentrations (64%) corresponded to samples in the SE direction, while those in the NE direction showed also a notable reduction in total I-TEQ (44%). In contrast, PCDD/F levels in vegetation samples from NW and SW directions were increased (37% and 6%, respectively). When the data were evaluated according to the distance of the sampling points to the plant, the highest decrease in total I-TEQ was found at 500 m from the stack. The results of this study seem to provide evidence for a decline in atmospheric emissions of PCDD/Fs in the area of Tarragona	Catalonia, Spain	Municipal Waste	1975	Longitudinal, Prospective	Vegetation: n=24	Vegetation	250m, 500m, 750m, 1000m, 1250m, 1500m from the stack in the 4 main wind directions (NE, NW, SE, SW)	None Specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
171	Soil	Schuhmacher, M., Xifro, A., Llobet, J. M., de Kok, H. A., and Domingo, J. L. 1997 Arch.Environ.Contam Toxicol. PCDD/Fs in soil samples collected in the vicinity of a municipal solid waste incinerator: human health risks	1 month	PCDD/PCDF Concentrations	N/A	soil samples were sieved through a 2mm mesh screen to achieve homogenous grain distribution. Determination of dry matter content was achieved by drying samples overnight at 130 C	Gas chromatograph y/mass spectrometer	Principal component analysis	24 soil samples	Yes the authors state that there isn't another likely source contributing to the TEQ levels in soil	Highest levels of TEQ concentrations were found at 750m and 3000m from the stack. Although soils around the MWI are polluted by PCDD/F the levels are similar to or lower than concentrations of previously reported soil samples around MWIs. The risk of adverse effects (other than cancer) derived from intake of these soils would not represent a serious	Entitat Metropolitana del Medi Ambient, Barcelona Spain	Low	Low	Moderate	Moderate	No
172	Vegetation	Schuhmacher, M., Domingo, J. L., Xifro, A., Granero, S., Llobet, J. M., and De Kok, H. A. M. 1998 Journal of Environmental Science and Health - Part A Toxic/Hazardous Substances and Environmental Engineering Presence of dioxins and furans in vegetation samples collected in the neighbourhood of a municipal solid waste	1 month	PCDD/PCDF Concentrations	samples collected and immediately packed in aluminum foil	Samples were dried at room temperature, kept in double aluminum foils and packed in labeled plastic bags until analysis	Gas chromatograph y/mass spectrometer	multivariate analysis, Principal component analysis	24 vegetation samples	highest TEQ levels were observed at distances <250 meters from the facility No PCA analysis to directly link emissions to incinerator	Highest levels of TEQ concentrations were found <250m from the MWI stack (range 2.33 - 2.05 ng.kg dry matter)	Entitat Metropolitana del Medi Ambient, Barcelona Spain	Low	Low	Moderate	Low	No
173	Soil	Schuhmacher, M., Domingo, J. L., Granero, S., Llobet, J. M., Eljarrat, E., and Rivera, J. 1999 Chemosphere Soil monitoring in the vicinity of a municipal solid waste incinerator: Temporal variation of PCDD/Fs	1 year	PCDD/F	Not specified	Storage not elaborated Samples were dried and sieved through 2mm mesh	HRGC/HRMS	multivariate analysis, Principal component analysis	Soil: 24	Yes, no other pollutant source could be found	PCDD/F concentrations in soils were not altered from 1996 to 1997. Increases and decreases identified could be explained by the heterogeneity of the samples The PCDD/F concentrations found are similar to or lower than the levels of PCDD/Fs in soils collected in the vicinity of MWIs from the Netherlands, USA and Spain	SIRUSA	Low	Low	Moderate	Moderate	No
174	Vegetation	Schuhmacher, M., Domingo, J. L., Llobet, J. M., Sunderhauf, W., and Muller, L. 7-30-1998 Sci.Total Environ. Temporal variation of PCDD/F concentrations in vegetation samples collected in the vicinity of a municipal waste incinerator (1996-1997)	1 year	PCDD/F concentrations	Vegetation: cut approx 4cm from the soil and packed in aluminum foils	Vegetation samples were dried at room temperature, kept in double aluminum foil, packed and labeled plastic bags and stored at room temperature until analysis	HRGC/HRMS	Principal component analysis; ANOVA	Vegetation: 24	Yes.	Levels of PCDD/F show a decreasing trend from 1996 to 1997 though the majority of these decreases were found not found to be statistically significant. Overall the study shows a general decrease in atmospheric PCDD/F concentrations in the area of Tarragona.	SIRUSA	Low	Low	Moderate	Moderate	No

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
175	Soil	Schuhmacher, M., Meneses, M., Granero, S., Llobet, J. M., and Domingo, J. L. 1997 Bull.Environ.Contam Toxicol. Trace element pollution of soils collected near a municipal solid waste incinerator: human health risk	N/A	Montcada, Spain	Municipal Waste	1975	Cross-sectional, prospective sampling	Soil: n=24	soil	100, 250, 500, 750, 1000, 1500, 2000, 3000 meters from the stack in the 3 main wind directions S, NE, NW	None Specified	N/A	N/A	N/A	N/A
178	Ambient Air; Woker Ambient Air	Shih, S. I., Wang, Y. F., Chang, J. E., Jang, J. S., Kuo, F. L., Wang, L. C., and Chang-Chien, G. P. 10-11-2006 J.Hazard.Mater. Comparisons of levels of polychlorinated dibenzo-p-dioxins/dibenzofurans in the surrounding environment and workplace of two municipal solid waste incinerators	Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) in the surrounding environment (outdoor) and workplace air of two municipal solid waste incinerators (MSWIs, T and M) were characterized and compared. T and M represented two typical municipal solid waste incinerators in the north of Taiwan, which have different processes for controlling the PCDD/F emissions. The results of this study are summarized as follows. (1) The total PCDD/F and the total PCDD/F WHO-TEQ concentrations in the workplace air were 5-13 and 5-15 times higher than those in the outdoor air, respectively. Obviously, it is worthwhile to explore more on health risk assessment for exposure of PCDD/Fs emitted from MSWIs, particularly in the workplace air. (2) Mean total PCDD/F I-TEQ concentrations in the outdoor air ranged between 0.0216 and 0.155 pg I-TEQ/Nm(3) and averaged 0.0783 pg I-TEQ/Nm(3) (0.0828 pg WHO-TEQ/Nm(3)) during two seasons for two MSWIs, which were 6.5-fold higher than that of a remote site (0.0119 pg I-TEQ/Nm(3) or 0.0132 pg WHO-TEQ/Nm(3)) in Taiwan. However, the above outdoor air concentration levels in the MSWIs were still much lower than the air quality limitation of PCDD/Fs (0.6 pg I-TEQ/Nm(3)) in Japan []. (3) PCDFs were the primary toxicity distributors for PCDD/Fs in the outdoor air, since the ratios of PCDDs/PCDFs (I-TEQ) at all sampling sites ranged from 0.180 to 0.492 and were less than unity. (4) The OCDD, OCDF, 1,2,3,4,6,7,8-HpCDD and 1,2,3,4,6,7,8-HpCDF were the four dominant species in both workplace and outdoor air near MSWIs. (5) By spraying water on and wetting	South Taiwan	2 Municipal Waste Incinerators	N/A	Longitudinal, Prospective	Surrounding Ambient Air: n=16 (4 per incinerator, and sampled in each season Workplace Ambient Air: n=16	Surroundin g ambient air, worker ambient air	Ambient air surrounding the MWIs were collected E, N, W, and S around 500m away from the stack Worker ambient air was collected within the incineration facility	None Specified	Ambient Air: n=14 (6 from Kenting, 8 from Pingtung)	Ambient Air	remote area and suburban area respectively	No
181	Soil; Fauna	Slob, W., Troost, L. M., Krijgsman, M., deKoning, J., and Sein, A. A. 2007 Govt.Reports Announcements.& Index.(GRA.&I), Issue.%20., 2094. Combustion of Municipal Solid Waste in the Netherlands: Emissions Occurring during Combustion Dispersal of Dioxins and the Associated Risks	Prepared in cooperation with Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer, Leidschendam (Netherlands). and Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek, The Hague (Netherlands) During the second half of 1989 high dioxin concentrations were found in cow's milk originating from areas located near municipal solid waste (MSW) incinerators. These findings led to a program for the measurement by TNO of the emissions from all Dutch MSW incinerators. This measurement program not only covered the emission of dioxins, but also of other components, in particular those mentioned in the Incineration Directive 1985 (RV'85). At each MSW incineration plant the Dutch Inspectorate of Public Health for Environmental Protection (IMH) carried out an ensuing inquiry, testing the emission measurements for compliance with licences and directives. At the same time RIVM investigated the dispersion and occurrence of dioxins in air, soil and among cattle (cow's milk), as well as exposure of and possible risks for the Dutch population. The results of these investigations were used to develop a mathematical model that can be used as a policy tool to estimate the risks of dioxin emissions and the consequences of policy measures	The Netherlands	Municipal Waste	N/A	Longitudinal	Soil: 17 Bovine Milk: unspecified Tissue: 4 bull, 2 cow, 2 sheep, 1 ram)	Soil, Bovine Milk and Animal Tissue	Locations within the depositional range of the 4 MWIs	None Specified	Backgroun d levels used but not elaborated	N/A	N/A	N/A
182	Fauna	Slob, W., Olling, M., Derks, H. J., and de Jong, A. P. 1995 Chemosphere Congener-specific bioavailability of PCDD/Fs and coplanar PCBs in cows: laboratory and field measurements	To estimate congener-specific bioavailabilities for 17 PCDD/Fs in cows grazing near a MSW incinerator both a controlled lab study and a field study were performed. In the lab study the estimates were derived from the elevated concentrations in milk from two cows after administration of a single dose of contaminated fly ash. In the field study, located near a large MSW incinerator, daily samples of grass and milk collected over a period of 60 days were pooled to two monthly bulk samples. The concentrations in these bulk samples of grass and milk were used to estimate the bioavailabilities of the 17 PCDD/Fs as well as of three coplanar PCBs. With the concentrations of PCDD/Fs expressed in I-TEQs the bioavailability in cows was estimated at +/- 7.5% in the field study. The congener-specific bioavailabilities correlated well between the two studies, as well as with previously reported values in the literature. However, the absolute levels differed considerably between studies, indicating a strong matrix effect	Netherlands	Municipal Waste	N/A	Longitudinal, Prospective	Grass Samples: n=2 Cows Milk Samples: n=2	Grass, Cows Milk	Two farms located in the vicinity of a MWI in the Netherlands	None Specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
175	Soil	Schuhmacher, M., Meneses, M., Granero, S., Llobet, J. M., and Domingo, J. L. 1997 Bull.Environ.Contam Toxicol. Trace element pollution of soils collected near a municipal solid waste incinerator: human health risk	1 month	PCDD/PCDF Concentrations	Soil samples collected from the upper 3cm of solum and put in polyethylene bags	soil samples were dried at room temperature and sieved through a 2mm mesh screen to achieve homogenous grain distribution.	Inductivly coupled mass spectrometry and hydride generation (As and Hg)	Kruskal-Wallis test, Mann-Whitney U test. Linear regression analysis was also applied	24 soil samples	Yes	Concentrations of metals increased with distance from the stack. Although soils around the MWI are polluted by metals the levels are similar to or lower than concentrations of previously reported soil samples around MWIs. According to the levels of most metals in the soils in the vicinity surrounding the MWI and the contribution to human daily intake derived from soil	Entitat Metropolitana del Medi Ambient, Barcelona Spain	Low	Low	Moderate	Moderate	No
178	Ambient Air; Woker Ambient Air	Shih, S. I., Wang, Y. F., Chang, J. E., Jang, J. S., Kuo, F. L., Wang, L. C., and Chang-Chien, G. P. 10-11-2006 J.Hazard.Mater. Comparisons of levels of polychlorinated dibenzo-p-dioxins/dibenzofurans in the surrounding environment and workplace of two municipal solid waste incinerators	N/A	PCDD/F concentrations	PS-1 sampler	Storage not elaborated.	HRGC/HRMS	None stated	Ambient Air: 32 Ambient worker air: 32 Control Ambient Air: 14	Indoor and outdoor sampled assumed to be correlated to incinerators. No alternative sources taken into account	Total PCDD/F concentrations in workplace air were 5-13 and 5-15 times higher than those in the outdoor air. Mean total PCDD/F concentrations in the outdoor air for the 2 seasons were higher than that of the remote sites in Taiwan. However these concentrations were much lower than the air quality limitation of PCDD/Fs in Japan	Not discussed.	Moderate	Moderate	Moderate	Low	No
181	Soil; Fauna	Slob, W., Troost, L. M., Krijgsman, M., deKoning, J., and Sein, A. A. 2007 Govt.Reports Announcements.& Index.(GRA.&I), Issue.%20., 2094. Combustion of Municipal Solid Waste in the Netherlands: Emissions Occurring during Combustion Dispersal of Dioxins and the Associated Risks	Unspecified	PCDD/F concentrations	Not elaborated.	Not elaborated	Not specified.	TEQ values	Soil: 17 Bovine Milk: unspecified Tissue: 4 bull, 2 cow, 2 sheep, 1 ram)	Yes, levels of chemical receptors in soil and fauna were in general higher than background levels	Dioxins in milk and soil were higher than in background levels.	Not discussed.	Low	Low	Low	Low	No
182	Fauna	Slob, W., Olling, M., Derks, H. J., and de Jong, A. P. 1995 Chemosphere Congener-specific bioavailability of PCDD/Fs and coplanar PCBs in cows: laboratory and field measurements	2 months	PCDD/F concentrations	Not specified	Grass and milk samples were stored at -20 C	GC/HRMS	None stated	Grass: 2 Cows Milk: 2	PCDD/F levels collected were assumed to be correlated to the MWI	PCDD/F levels in cows milk collected from areas under the influence of the MWI were higher than those found in the laboratory study. Reasons for this may be attributed to particle-bound dispersion and distribution, and particle size distribution.	Not discussed.	Low	Low	Moderate	Low	No

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
186	Ambient Air	Takasuga, T., Inoue, T., Ohi, E., and Kumar, K. S. 2004 Arch.Environ.Contam Toxicol. Formation of polychlorinated naphthalenes, dibenzo-p-dioxins, dibenzofurans, biphenyls, and organochlorine pesticides in thermal processes and their occurrence in ambient air	Mono- through octachlorinated naphthalenes (PCNs) were measured in start-up, steady operation, and shutdown of machinery operation flue gas and fly ash generated during different stages of MSWI and other incineration thermal processes. Besides, electroprecipitator fly ash (EP-ash) was dechlorinated using the Hagenmeier process and analyzed for congener profiles. In addition to PCNs, polychlorinated dibenzo-p-dioxins (PCDDs), dibenzofurans (PCDFs), biphenyls (PCBs), and major organochlorine pesticides were determined in ambient air samples from three different sites of western Japan in the summer and winter of 1992. The PCNs from flue gas contained 15,000, 4300, and 13,000 ng/m3 during start-up, steady operation, and shutdown conditions, respectively. Whereas fly ash contained 470, 370, and 1400 ng/g PCNs under start-up, steady operation, and shutdown condition, respectively. The dechlorination process reduced PCN concentrations considerably. Concentrations of PCNs and PCDD/PCDFs in air samples collected in winter were slightly higher than in summer. PCBs, organochlorine pesticides such as chlordanes, DDTs, and HCHs were higher in summer air samples. WHO toxic equivalency (WHO-TEQ) concentrations in air samples were 0.3-0.9 pg/m3 for PCDD/DFs and 0.029-0.31 pg/m3 for dioxin-like PCBs	Japan	Municipal Waste	N/A	Longitudinal, Prospective	Ambient air: not specified	Ambient Air	Not specified. 3 locations, each with different magnitudes of contamination	None Specified	N/A	N/A	N/A	N/A
188	Worker Ambient Air	Tharr, D. 1991 Applied Occupational and Environmental Hygiene Workplace Exposures at a Waste-to-Energy Facility	Breathing zone and environmental samples were analyzed for total and respirable dust, crystalline silica (14808607), asbestos (1332214), hexavalent-chromium (18540299) (Cr+6), carbon-monoxide (630080), nitrogen oxides, and trace metals at a waste to energy conversion facility. The facility typically incinerated municipal trash at approximately 1400 degrees-F and produced steam in two 360 ton capacity boilers that was sold directly or converted to electricity by means of an on site turbine. The facility operated 24 hours a day and usually employed 50 persons. Workplace temperature and humidities were also measured. Total dust concentrations ranged from 1.2 to 11.5mg/m3. Breathing zone respirable dust concentrations were 0.3 to 0.7mg/m3. Significant concentrations of airborne aluminum (7429905), cadmium (7440439), chromium (7440473), copper (7440508), iron 7439896), nickel (7440020), and lead (7439921) were detected. Soluble Cr+6 was not detected. Insoluble Cr+6 was detected at concentrations on the order of 0.001mg/m3. Significant amounts of amosite (12172735) were detected in the breathing zone and	N/A	Municipal Solid Waste	Not specified.	Cross-Sectional	Worker ambient air: n=12 Surface wipes	Worker ambient air Surface wipes	Within the incinerator	None Specified	N/A	N/A	N/A	N/A
191	Ambient Air; Soil; Vegetation	Wang, J. B., Wang, M. S., Wu, E. M., Chang-Chien, G. P., and Lai, Y. C. 4-15-2008 J.Hazard.Mater. Approaches adopted to assess environmental	Different approaches were carried out in this work to assess environmental impacts of a municipal solid waste incinerator. A total of seven sites in the vicinity of the facility were chosen to collect air, banyan leaf and soil samples for analyses of PCDD/Fs by high-resolution gas chromatography/high-resolution mass spectrometry. Based on the PCDD/F concentrations of the three matrices determined at sites upwind, downwind and area of maximum ground concentration, it was found that the environmental impact of the MSWI was not obvious. PCDD/F concentration isopleths of the three environmental compartments coupled with wind rose of the region proved that the influence of the MSWI on the environment was also	Northern Taiwan	Municipal Waste	N/A	Cross sectional	ambient air samples were taken continuously Soil: n=9 Vegetation: not specified	Ambient air, ambient soil, Banyan leaves (vegetation)	within a radius of 3km to 5km from the MWI	None Specified	N/A	N/A	N/A	N/A
192	Soil	Wilcke, W., Amelung, W., and Zech, W. 1997 Zeitschrift fuer Gastroenterologie Heavy metals and polycyclic aromatic hydrocarbons (PAHs) in a rural community leewards of a waste incineration plant	In a rural community (Stephanskirchen, southern germany) Near a waste incineration plant 7 soils, sewage sludge, waste incineration residues, the gutter sediment of a family home, and mosses were sampled to determine the total concentrations of cd, pb, zn and 20 pahs. Representative samples were used to measure nh4no3- and edta-extractable cd, pb, and zn as well as 20 pahs in particle size separates (Clay, silt, fine and coarse sand). Sites near the main road, hill top, and forested sites contain up to 1.24 Mg cd, 888 mg pb, and 279 mg zn per kg. The heavy metal concentrations of the sewage sludge, the gutter sediment, and especially the waste incineration residues are extremely high (Up to 57 mg cd, 3300 mg pb, and 5700 mg zn per kg). The extractability of pb and zn with nh4no3 is low (< 5%), That with edta is high (Up to 71.2% Of total cd, 82.5% Of total pb, and 47.2% Of total zn). The sum concentrations of pahs range between 0.4 And 470 mg kg-1. The silt has the h	Stephanskirchen, Southern Germany	Municipal Waste	N/A	Cross sectional	Soil: n=6	Soil	Areas within the vicinity of the incinerator (no actual locations given, i.e. 3 kms from the stack)	None Specified	N/A	N/A	N/A	N/A
194	Ambient Air	Wu, Y. L., Lin, L. F., Hsieh, L. T., Wang, L. C., and Chang-Chien, G. P. 5-21-2008 J.Hazard.Mater. Atmospheric dry deposition of polychlorinated dibenzo-p-dioxins and dibenzofurans in the vicinity of municipal solid waste incinerators	This study focuses on the atmospheric dry deposition flux of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) in the vicinity of the two municipal solid waste incinerators (MSWIs) located in southern Taiwan. PCDD/Fs in ambient air were taken and analyzed for seventeen 2,3,7,8-substituted PCDD/Fs during November 2004 and July 2005. Results show that the mean concentrations of PCDD/Fs in the ambient air near MSWI-GS and MSWI-RW were 0.090 and 0.097pg I-TEQ/Nm(3), respectively. Dry deposition fluxes of total PCDD/Fs were 18.0 and 23.5pg I-TEQ/(m(2)d) in the ambient air near MSWI-GS and MSWI-RW, respectively, which were considerably higher than that measured in Guangzhou, China. Annual dry deposition fluxes of total PCDD/Fs in the ambient air near MSWI-GS and MSWI-RW were 189 and 217ng/(m(2)year), respectively, which were also much higher than dry deposition of total PCDD/Fs to the Atlantic Ocean. The results of the present study strongly suggest that exposure to PCDD/Fs in this area should be reduced. In addition, parametric sensitivity shows that dry deposition flux of PCDD/Fs is most sensitive to dry deposition velocity of the particle-phase, followed by air temperature and concentration of total suspended particulate but least sensitive to dry deposition velocity of the gas-phase	Southern Tawian	2 Municipal Waste Incinerators	N/A	Longitudinal, Prospective	Ambient Air: 56 (7 from each incineration facility in all 4 seasons)	Ambient Air	Samples collected from the prevailing wind directions (N, NW). Some upwind sites were also selected. Actual locations (in meters or Kms) were not stated.	None Specified	N/A	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
186	Ambient Air	Takasuga, T., Inoue, T., Ohi, E., and Kumar, K. S. 2004 Arch.Environ.Contam Toxicol. Formation of polychlorinated naphthalenes, dibenzo-p-dioxins, dibenzofurans, biphenyls, and organochlorine pesticides in thermal processes and their occurrence in ambient air	1 year	PCNs, PCBs, PCDD/Fs, organochlorine pesticides	high volume air sampler	Not elaborated.	HRGC/HRMS	None stated	Not stated	emissions assumed to be from incinerator	Concentrations of PCNs and PCDD/Fs in air sample collected in winter were slightly higher than in summer. PCBs, organochlorine pesticides were higher in summer samples.	Not discussed.	Low	Low	Moderate	Low	No
188	Worker Ambient Air	Tharr, D. 1991 Applied Occupational and Environmental Hygiene Workplace Exposures at a Waste-to-Energy Facility	1 day	respirable particulates; crystalline silica; asbestos; hexavalent chromiuml trace metals	Not stated	Not elaborated	Not Stated	None stated	unspecified	Yes, chemical concentrations were assumed to be from the incinerator	Breathing zone respirable dust concentrations were 0.3 to 0.7mg/m3. Significant concentrations of airborne aluminum (7429905), cadmium (7440439), chromium (7440473), copper (7440508), iron 7439896), nickel (7440020), and lead (7439921) were detected. Soluble Cr+6 was not	Not discussed.	Low	Low	Low	Low	No
191	Ambient Air; Soil; Vegetation	Wang, J. B., Wang, M. S., Wu, E. M., Chang-Chien, G. P., and Lai, Y. C. 4-15-2008 J.Hazard.Mater. Approaches adopted to assess environmental	1 month	PCDD/F	Ambient air: PS-1 air sampler Soil: not specified Vegetation: immediately packed in aluminum foils	Ambient air: not specified Soil and vegetation: naturally weathered indoors to dryness	HRGC/HRMS	Principal component analysis	ambient air samples were taken continuously Soil: n=9 Vegetation: not specified	Incinerator is not the only source of ambient air, soil and vegetation contamination in the area	From the samples at the 7 sites within the vicinity of the MWI the authors found that the impact from the MWI was not obvious. The PCDD/F concentration isopleths correlated well with the	Not discussed.	Low	Moderate	Moderate	Moderate	No
192	Soil	Wilcke, W., Amelung, W., and Zech, W. 1997 Zeitschrift fuer Gastroenterologie Heavy metals and polycyclic aromatic hydrocarbons (PAHs) in a rural community leewards of a waste incineration plant	N/A	PAHs	Not elaborated.	Soil samples were sieved and dried prior to analysis. Storage not elaborated	GC/MS	multivariate analysis, Principal component analysis	Soil: 8	Incinerator is not the primary source of PAH contamination	Exhausts of diesel fuel and gasoline emissions are the main sources of PAHs except for the gutter sediment. The emissions from the MWI for not significantly contribute to the contamination of samples.	Not discussed.	Low	Low	Moderate	Moderate	No
194	Ambient Air	Wu, Y. L., Lin, L. F., Hsieh, L. T., Wang, L. C., and Chang-Chien, G. P. 5-21-2008 J.Hazard.Mater. Atmospheric dry deposition of polychlorinated dibenzo-p-dioxins and dibenzofurans in the vicinity of municipal solid waste incinerators	1 year	PCDD/F concentrations	Polyurethane foam (PUF) sampler	Not elaborated.	HRGC/HRMS	N/A	Ambient Air: 56	Yes	Mean concentration of PCDD/Fs in ambient air around 2 MWIs (industrial area) were 0.090 and 0.097. Dry deposition fluxes for total PCDD/F in the ambient air were 18.0 and 23.5 pg I-TEQ/(m^2d), these were considerably higher than those measured in an urban area with no industrial influences (no p-value reported). Annual total dry depositions of PCDD/Fs were also higher than the dry deposition to the Atlantic Ocean (again, no p-	Not discussed.	Low	Moderate	Moderate	Low	No

Source				Incinerator			Study Design	Study Group				Control Group			
Ref ID	Media	Citation	Abstract	Location of Incinerator	Type of Incinerator	Operation Start Date	Study type	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals	Number of Samples Taken	Type of Sample Taken	Location of Samples with respect to Incinerator	Prior Exposure to Chemicals
213	Vegetation	Martin, M., Robin, D., and Haerdi, W. 1994. La Societe. Oak Leaves as Bioindicators of Heavy Metals Emissions near an Incineration Plant	The analysis of heavy metals in oak leaves exposed to heavy metal fall out from an incineration plant situated in the vicinity, allows these leaves to serve as bioindicator of pollution. These analyses were mainly done by ICP-AES and flameless atomic absorption spectrometry. A heavy metal fall out map indicating the sites which are most exposed to pollution has been drawn.	3 facilities in Switzerland	Municipal Waste	Not indicated.	Cross sectional, longitudinal	Not specified.	Oak Leaves; Rain	Within several kilometers.	None specified.	No control group.	N/A	N/A	N/A

Source			Methods/Analytical Procedure					Results				Miscellaneous	Quality Assessment				Final Result
Ref ID	Media	Citation	Study Duration	Chemicals/ Outcome Assessed	Samples Collected In	Sample Storage Method	Analysis Method	Type of Statistical Analysis Performed	Sample Size	Correlation of Chemical Levels to Incinerator	Key Conclusions	Funding Source	Study Design	Study/Control Group Selection	Sample Collection	Critical Results Analysis	Include?
213	Vegetation	Martin, M., Robin, D., and Haerdi, W. 1994. La Societe. Oak Leaves as Bioindicators of Heavy Metals Emissions near an Incineration Plant	1 year (1992-1993)	Cd, Zn, Pb	Not elaborated.	Not specified.	ICP-AES	Basic charting.	unspecified	Distance decay effect	Oak leaves can be a suitable bioindicator for heavy metals. A distance decay effect was observed. Further study necessary to make scientifically justifiable conclusions.	Not discussed.	Moderate	Very Low	Low	Low	No

APPENDIX D

Grey Literature Data Abstraction

APPENDIX D-1

Grey Literature Pertaining to Both Environmental Monitoring and Human Biomonitoring

<u>Grey Literature Data Abstraction</u>

Author/Organization: Alberta Health and Wellness

Title: Swan Hills Treatment Centre; Long-term follow-up Health Assessment Program (1997-2002)

Date of Publication: June 2004

Location: Alberta, Canada

Facility (if specified): *Special Waste Treatment Centre (Hazardous waste – PCB contaminants)*

Type of Monitoring: Environmental Monitoring and Human Biomonitoring

Environmental Monitoring Summary:

Deer and Moose

Field Collection	Methodology	Chemical Agents
• 10km, 20km, 30km from facility • Road kill from other areas acted as a control • Frozen moose and deer samples were taken from local (within 30km from facility) residents and First Nations	• Sample of liver, fat and muscle were used to determine chemical agents present	• PCB's • PCDD/F

Conclusions:

Overall levels of ΣPCBs in the liver and muscle in 2001 and 1999 declined as compared to the 1997 levels (Figure 3-8 A and Figure 3-8 B). The levels of ΣPCBs TEQ increased in the liver in 2001, as compared to those in the 1997 and 1999 studies. Overall, levels of ΣPCBs TEQ in the muscle in 2001and 1999 declined as compared to the 1997 levels.

Fish

Field Collection	Methodology	Chemical Agents
• Crystina Lake (1.5km NE of facility) • Roche Lake (20km E of facility) • Chip Lake (reference lake)	• Samples of liver and muscle were used to determine chemical agents present • Scales	• PCB's • PCDD/F • MethylMercury

Conclusions

The mean concentrations of ΣPCDD/Fs, ΣPCBs and ΣTEQ in the muscle and liver samples in brook trout from Chrystina Lake in 2000 were significantly declined as compared to those in 1997.

The average concentrations of total mercury in brook trout from Chrystina Lake were less than 200 µg/kg in 1999 and 2001.

Human Biomonitoring Summary:

Area under Study	Demographic Characteristics	Methodology	Chemical Agents
• Town of Swan Hills • All communities within a 100 km radius, including Fox Creek, Little Smoky, Sunset House, High • Prairie, Enilda, Joussard, Driftpile, Faust, Kinuso, Canyon Creek, Widewater, Slave Lake, Fort • Assiniboine and Swan Hills	• >18 years • Resided in communities in the Swan Hills area Participated in the 1997 • Swan Hills Health Assessment Survey	• Contact potential participants via telephone survey. • Collect Blood samples at hospitals	• PCB’s • PCDD/F

Conclusions

Concentrations of PCBs and PCDD/Fs in blood are similar in residents living the Swan Hills area in 1997 and 2001 surveys. TEQ values of PCDD/Fs in the 2001 survey are higher than those in the 1997 survey. The higher TEQ values can be attributed to higher levels of 1,2,3,6,7,8- HxCDD and 1,2,3,7,8-PeCDD.

APPENDIX D-2

Grey Literature Pertaining to Environmental Monitoring Programs

<u>Grey Literature Data Abstraction</u>
Author/Organization: Environmental Agency

Title: Incinerator Sector Guidance Note IPPC S5.01

Date of Publication: 2003

Location: United Kingdom

Facility (if specified): *All incineration types*

Type of Monitoring: Environmental Monitoring

Environmental Monitoring Summary:

Environmental monitoring may be required, for example, when:
- there are vulnerable receptors
- the emissions are a significant contributor to an Environmental Quality Standard (EQS) that
- may be at risk
- the Operator is looking for departures from standards based on lack of effect on the environment;
- to validate modelling work.

The need should be considered for:
- groundwater, where it should be designed to characterize both quality and flow and take into account short- and long-term variations in both. Monitoring will need to take place both upgradient and down-gradient of the site
- surface water, where consideration will be needed for sampling, analysis and reporting for
- upstream and downstream quality of the controlled water
- air, including odour
- land contamination, including vegetation, and agricultural products
- assessment of health impacts
- noise

Where environmental monitoring is needed, the following should be considered in drawing up proposals:
- determinands to be monitored, standard reference methods, sampling protocols
- monitoring strategy, selection of monitoring points, optimization of monitoring approach
- determination of background levels contributed by other sources
- uncertainty for the employed methodologies and the resultant overall uncertainty of measurement
- quality assurance (QA) and quality control (QC) protocols, equipment calibration and maintenance, sample storage and chain of custody/audit trail
- reporting procedures, data storage, interpretation and review of results, reporting format for the provision of information for the Regulation

Monitoring surveys will need to be established where sensitive soil systems or terrestrial ecosystems are at risk from indirect emission via the air (i.e. deposition related), or direct impacts of any on site waste storage and treatment operations.

Grey Literature Data Abstraction
Author/Organization: Cenci R.M., Sena N., Filippi G., Umlauf G.M., Beone G., Lodigiani W., Gaulio L., Musmeci A., Benedetti R.,

Title: Monitoring During Time of Relapses of an Incineration Plant

Date of Publication: October 2007

Location: Parona, Italy

Facility (if specified): *Municipal Waste Incinerator*

Type of Monitoring: Environmental Monitoring During Time of Relapse

Environmental Monitoring Summary:

Area Studies	Environmental Media	Methodology	Chemical Agents
- 65 Km^2 around Incinerator	- 42 Soil Samples (0-30 cm layer) - 42 Moss Samples	- For Soil: L.U.C.A.S. net (Land Use Cover Area from Statistical Survey) - For Moss: A.N.P.A. guide lines (1999) - For preparation and treatment samples: Method I.S.O. n. 11466	- Trace elements (in soil and moss samples) - Al, Cd, Cr, Cu, Hg, Ni, Pb, Zn - Dioxins and furans (in soil samples)

Conclusions
The fallout of heavy metals, both of anthropogenic or natural origin, has been evaluated through the use of mosses as bio-indicators. The research campaigns (in 2002 and 2005) did not show any increase in heavy metals concentrations in soils, through fall-out from the incinerator

The measured values are of a similar order of magnitude to the concentrations measured at agricultural sites and are lower than those measured in some urban and industrial areas

Authors conclude that impact of the incinerator plant at Parona has been rather small but long-term studies are considered essential to monitor the impact on the environment of fall-out in the study area, as well as the correct operation of the plant.

<u>Grey Literature Data Abstraction</u>

Author/Organization: Greater Vancouver Regional District

Title: Energy from Waste Fact Sheet

Date of Publication: June 2007

Location: Burnaby, British Columbia

Facility (if specified): *Municipal Waste Incinerator; Energy from Waste Facility*

Type of Monitoring: Environmental Monitoring

Environmental Monitoring Summary:

The Lower Fraser Valley Air Quality Monitoring Network continuously monitors the ambient air environment at 30 sites throughout the Lower Mainland. No measurable impact has ever been found from the WTEF.

Grey Literature Data Abstraction

Author/Organization: Agency for Toxic Substances and Disease Registry

Title: A Guidance Manual for Public Health Assessors

Date of Publication: March 2002

Location: United States

Facility (if specified): *Hazardous Waste Incinerator*

Type of Monitoring: Environmental Monitoring

Environmental Monitoring Summary:
Ambient air monitoring (Chapter 6.1.2.1.):

Incineration sites should utilize ambient air monitors of the stack data or RA indicates the potential for air releases of contaminants at concentrations that could cause adverse health effects. Ambient air monitors should be located at the fence line of the facility are where air dispersion modeling indicates that people could be exposed to emissions at potentially harmful levels. Fence-line monitoring stations should be placed in the predominant wind direction(s) near where the fugitive emissions are likely to be generated or detected.

One to four chemicals should be chosen as indicators of exposure to site contaminants. Criteria for the selection of such compounds include:

- Method Available: chemicals that can be easily and quickly identified, preferably on a continuous basis, or at least a frequent basis (not greater than 15 minutes b/n sampling and report of results)
- Detectable concentrations
- Unique: not likely to be from other sources
- Representative: of the various classes of chemicals present
- Toxicity: present on site in concentrations that could cause adverse health effects

In addition to ambient air monitoring, time weighted ambient air samples should be taken at 8 hour or 24 hours intervals etc.

Air sampling should begin prior to facility construction to establish baseline levels.

Air sampling should provide:

- Data necessary to access episodic and chronic exposures
- Assurance of worker protection
- On-Site action levels and response actions
- Fence line action levels and response actions
- Community action levels and response actions
- S&A for contaminants of health concern
- Sampling to verify real-time monitoring results
- Sampling during facility operations

Grey Literature Data Abstraction

Author/Organization: Environmental Protection Department of Hong Kong

Title: The Chemical Waste Treatment Centre; Environmental Monitoring

Date of Publication: June 2002

Location: Hong Kong

Facility (if specified): *Hazardous Waste Incinerator*

Type of Monitoring: Environmental Monitoring (Ambient Air)

Environmental Monitoring Summary:

Environmental Media	Area Studied	Frequency of Sampling	Methodology	Chemical Agents
-Ambient Air	-Rooftop of facility -Estate near the facility (no actual distance given)	-Every 6 months -Monitoring for dioxins is carried out once a month	-Procedure for ambient air monitoring follows the USEPA method T09.	-Particulates -Sulphur dioxide -Nitrogen dioxide -Volatile organic compounds -Polychlorinated biphenyls -Dioxins

Conclusions:

Monitoring results in the past two years show that the average dioxin levels in the ambient air close to the CWTC are in the range of 0.053 to 0.069 pg I-TEQ/m3 which are within the normal range found in other parts of Hong Kong.

Grey Literature Data Abstraction

Author/Organization: Lorber et al.; Walker et al.

Title: Environmental Monitoring at a United States Naval Air Facility Adjacent to the Shinkampo Industrial and Medical Waste Incineration Complex in Atsugi, Japan

Date of Publication: 2002

Location: Atsugi, Japan

Facility (if specified): *Industrial and Medical Waste Incinerators*

Type of Monitoring: Environmental Monitoring

Environmental Monitoring Summary:

Two papers were published in the scientific journal *Organohalogen Compounds* which were retrieved through the grey literature and external contact process (Lorber et al., 2002; Walker et al., 2002). The papers describe air and soil monitoring at a United States Naval Air Facility adjacent to the Shinkampo industrial and medical waste incineration complex in Atsugi, Japan. The incinerator was in operation until May of 2001. Through the spring and summer, the prevailing winds directed stack emissions directly over the naval base. The US Navy was not permitted to test the stack nor were they able to obtain stack emissions data from the facility. As a result, an air and soil monitoring program for PCDD/Fs was established at the base, which led into a human health risk assessment. Surface soil samples were taken at 73 sites, and an additional 25 subsurface samples were taken at these sites. Sampling occurred in both areas of concern and reference areas. As expected surface soil samples had a higher TEQ level than subsurface samples. A clear distinction was observed between TEQ levels in downwind sites within 500 m of the incinerator and other, less impacted sites. Congener profiles compared well in all samples except one anomalous sample, and also compared well to a sample taken near a municipal waste incinerator in Columbus, Ohio. The authors concluded that where soil is impacted, the impacts are mostly retained at the surface, and dilution increases rapidly with depth. The authors also looked at indoor dust samples and concluded that only light, fine soil particles or airborne particulate matter are transferred indoors.

With regards to air quality monitoring, five outdoor and 7 indoor sampling locations were selected throughout the naval facility. 344 outdoor and 67 indoor samples were taken during 6 individual days spread out over several months. An average I-TEQ of 1.57 pg/m^3 was detected as compared to 0.12 and 0.017 pg/m^3, which are the average urban and rural PCDD/F concentrations in the United States. Highest concentrations were observed in a maintenance building directly downwind of the facility. Congener profile analysis showed strong comparison between impacted sites in Atsugi and in Columbus, Ohio at a municipal waste incinerator, and between background sites in Atsugi and Columbus, Ohio.

Grey Literature Data Abstraction

Author/Organization: Wood Buffalo Environmental Association

Title: Human Exposure Monitoring Program; 2006 Monitoring Year

Date of Publication: 2007

Location: Wood Buffalo Region, Alberta, Canada

Facility (if specified): *Not Specified*

Type of Monitoring: Environmental Monitoring (Air)

Environmental Monitoring Summary:

The human exposure monitoring program was designed to obtain measures of exposure to a variety of contaminants across a continuum of exposure, including measure of contaminants on the environment and the quantity of contaminants to which an individual is exposed through these sources.

Areas Studied	Demographic and Socioeconomic Characteristics	Chemical Concentrations Measured	Methodology
Fort MacKay Fort McMurray First Nations Gregoire Kaje/Anzac)	age, sex, income, living conditions, employment characteristics, length of residence, marital status, and smoking characteristics	NO_2, SO_2, O_3 VOC's: Benzene, Decane, Ethylbenzene, Heptane, Hexane, Limonene, 3 – methylhexane, m,p – eylene, N – propylbenzene, Nonane, Octane, o – xylene, Toluene	Ambient Air monitoring stations, personal (monitor wore in participants breathing zone) indoor (in the home of the participant), outdoor (outside the participants home) Demographic and exposure survey's, and time activity diaries.

Conclusions:

NO_2, SO_2 and O_3 levels were low compared to existing guidelines.

Indoor sources of VOC's were the predominant factor affecting personal exposure (i.e. tobacco smoke, occupation, off-gassing from consumer products)

APPENDIX D-3

Grey Literature Pertaining to Human Biomonitoring Programs

<u>Grey Literature Data Abstraction</u>

Author/Organization: Schoeters, Greet. VITO

Title: Next Steps in the Human Biomonitoring Project

Date of Publication: Not Available

Location: Belgium

Facility (if specified): *Municipal Waste Incineration*

Type of Monitoring: Human Biomonitoring

Human Biomonitoring Summary:

Follow-up presentation on the next steps for the Flanders Human Biomonitoring Project. With relation to waste incineration the study plans to research the following

- Neuro-psychological development of children
    - 209 children
    - 42 months
    - 4 areas (Rural, Non ferro, Waste incinerators, Harbours)

<u>Grey Literature Data Abstraction</u>
Author/Organization: French Institute for Public Health Surveillance

Title: French Dioxin and Incinerators Study

Date of Publication: October, 2008

Location: France

Facility (if specified): *Municipal Waste Incineration*

Type of Monitoring: Human Biomonitoring

Human Biomonitoring Summary
This document discusses the Dioxin Burden in a population surrounding various municipal waste incinerators (of varying age and technology) in France.

Population Studied	Methodology	Chemical Agents
• 2069 randomly selected, of that 1053 people aged 30-65 years lived in the study area for at least ten years • Have no occupational exposure to dioxins • Have not breast-fed (or very briefly).	• Subjects were randomly selected • In a face-to-face interview, they answered a questionnaire about their individual characteristics, their food habits, and their domestic environment. • Finally blood samples for dioxin and PCB (polychlorinated biphenyls) assays were taken and sent for analysis to the reference laboratory at the University of Liège in Belgium (CART laboratory).	• PCDD • PCB

Conclusions
The burden study shows that the dioxin concentrations measured nowadays in the blood of persons living near incinerators are not statistically higher than in non-exposed persons. We note nonetheless that the farmers eating local animal products (meat, dairy products, and eggs) and living near old highly polluting incinerators had a statistically higher blood dioxin concentration than those who were unexposed. This difference was not found around the incinerators meeting EU standards

<u>Grey Literature Data Abstraction</u>
Author/Organization: Commission of the European Communities

Title: Technical Annexed to the communication of the commission on the European Environment and Health Action Plan 204-2010 (Specifically Action 3)

Date of Publication: 2004

Location: Europe

Facility (if specified): *Not Specified*

Type of Monitoring: Human Biomonitoring

Human Biomonitoring Summary:

The Commission sets out to set up a coherent approach for human biomonitoring in Europe. This document outlines the approach that the EU will use to establish an effective monitoring program in EU.
The document outlines the 3 step in the development of a human biomonitoring program:

2004-2007: set up a multidisciplinary working group to develop a coordinated approach for biomonitoring based on existing expertise and experiences. They will examine the range of objectives and ensure that the program will be cost-efficient. Use the methodology from Member States' surveillance programs as a guide.

2006: test the approach developed with a Pilot Project in collaboration with the Member States. This will develop the necessary tools for coordination, identify possible problems and facilitate the establishment of collaboration and the sharing of methodologies.

2004-2007: The commission will identify how biomonitoring results can be integrated most efficiently with environmental monitoring data, and will develop strategies for communicating biomonitoring results so as to allow for adequate response.

Grey Literature Data Abstraction

Author/Organization: Elly Den Hond; Environmental Toxicology, VITO

Title: Biomonitoring Results, International Symposium organised by the Flemish Center of Expertise for Environment and Health December 15,2006

Date of Publication: 2006

Location: Belgium

Facility (if specified): *Not Specified*

Type of Monitoring: Human Biomonitoring

Human Biomonitoring Summary:

Study Population	**Timeline**	**Biological Materials**	**Chemical Agents**
1200 newborns and mothers	Sept 2002-Dec 2003	Umbilical Cord Blood Questionnaires Medical files of maternity	Persistent Chlorinated Compounds (serum) Heavy Metals (blood)
1600 adolescents (14-15y)	Oct 2003 – July 2004	Blood Urine Questionnaires Medical files of school dr.'s	Persistent Chlorinated Compounds (serum) Heavy Metals (blood) Metabolites of PAH and benzene (urine)
1600 elderly adults (50-65y)	Sept 2004 – June 2005	Blood Urine Questionnaires	Persistent Chlorinated Compounds (serum) Heavy Metals (blood) Metabolites of PAH and benzene (urine)

Determinants of Exposure:

- Sex
  - higher in males for adolescents
  - higher in females for elderly
- Age
- Body-mass index, weight change
  - for persistent lipophylic compounds
- Smoking
  - for cadmium, lead, PAH and benzene
- Nutrition
  - fat products for persistent lipophylic compounds
  - vegetables for cadmium and lead (in elderly)
  - local products
  - breast feeding in adolescents
- Area remains significant

<u>Grey Literature Data Abstraction</u>

Author/Organization: Expert Team to Support BIO monitoring in Europe

Title: Development of a coherent approach to human biomonitoring in Europe

Date of Publication: December 2007

Location: Europe

Facility (if specified): *None Specified*

Type of Monitoring: Human Biomonitoring

Human Biomonitoring Summary:

This document outlines the general approach to be taken when conducting human biomonitoring studies. The objective of the ESBIO is to understand the links between sources of pollution and health effects. In order to achieve this the human biomonitoring study had to be conducted in the coherent and harmonized approach throughout EU by means of commonly developed protocols, strategies and scientific tools ensuring reliable and comparable data, while also leading to a more effective use of resources involved.

The document also outlines urine as raking superior to blood (invasive, more critical to collect, ethical concerns) and to hair (limited to only a few widely accepted biomarkers)

There is no actual data on the media and sampling frequency of specific biomonitoring activities.

Grey Literature Data Abstraction
Author/Organization: German Environmental Survey for Children (GerES IV)

Title: German Environmental Survey for Children

Date of Publication: 2005

Location: Germany

Facility (if specified): *Not Specified*

Type of Monitoring: Human Biomonitoring

Human Biomonitoring Summary:

- **Whole blood** During the blood sampling conducted for the Health Survey, an additional collection tube (Blaukopf vacutainer containing the anticoagulant sodium heparin) are filled, as follows:

  - for children aged between 3 and 6 years with 2 ml (for lead, cadmium, mercury);

  - for children aged 7 to 14 years with 6 ml (for lead, cadmium, mercury and organochlorine compounds such as PCBs, DDE, HCB, HCH);

  - for all children five fungi-specific IgE in addition to a panel test in 200 µl serum.

- **Sample of morning urine** (total volume of urine) If diapers are no longer worn at night samples are taken in 750 ml ”toilet inserts” (for girls possibly until the age of 6 years, in consultation with their parents). From the age of 5 years 1 l wide-neck polyethylene flasks are used. The pollutants analysed are:

  - for all children: creatinine, arsenic, cadmium, mercury, nickel, nicotine, cotinine;

  - for children from the age of 8 years: cortisol, adrenalin and noradrenalin;

  - in 600 randomly selected samples from children of all ages: pentachlorophenol (PCP) and other chlorophenols, metabolites of pyrethroids, organic esters of phosphoric acid and PAHs

<u>Grey Literature Data Abstraction</u>

Author/Organization: Schoeters ,G., VITO Belgium

Title: The Flemish Human Biomonitoring program; the causal chain: from exposure to effects

Date of Publication: 2007

Location: Belgium

Facility (if specified): *Not Specified*

Type of Monitoring: Human Biomonitoring

Human Biomonitoring Summary:

The goal of the Flemish Human biomonitoring program is to identify baseline values or reference values for environmental pollutant in the Flemish population, to establish if physical location impacts pollutant levels and potential biological effects, and to perhaps find a relation between exposure and early effects at the current exposure levels.

Study Population	Timeline	Biological Materials	Chemical Agents
1200 newborns and mothers	Sept 2002-Dec 2003	Umbilical Cord Blood Questionnaires Medical files of maternity	Persistent Chlorinated Compounds (serum) Heavy Metals (blood)
1600 adolescents (14-15y)	Oct 2003 – July 2004	Blood Urine Questionnaires Medical files of school dr.'s	Persistent Chlorinated Compounds (serum) Heavy Metals (blood) Metabolites of PAH and benzene (urine)
1600 elderly adults (50-65y)	Sept 2004 – June 2005	Blood Urine Questionnaires	Persistent Chlorinated Compounds (serum) Heavy Metals (blood) Metabolites of PAH and benzene (urine)

Locational criterion: 8 study areas in Flanders representing typical and different environmental loads (representing 20% of the Flanders region)

Urban regions: Antwerp, Ghent

Rural areas: Rural Flanders, Fruit orchard region

Industrial areas: Seaport Antwerp/Ghent, Non ferro metallurgic, Petrochemical, Waste incinerator regions

Conclusions: Area of residence is a determinant of exposure. No alarming trends were detected. People living in rural areas have a high exposure to persistent chlorinated compounds. Cadmium is problematic in some regions. DDT metabolites are still detected in the human body in considerable amounts. Factors such as age, gender, smoking, and nutritional intake are important determinants of exposure.

APPENDIX D-4

Grey Literature with No Specified Monitoring Program

<u>Grey Literature Data Abstraction</u>
Author/Organization: Dyke P.

Title: Dioxins and furans and other incineration-related issues

Date of Publication: 2004

Location: United Kingdom

Facility (if specified): *Not specified*

Type of Monitoring: Not specified – Just general comments.

Monitoring Summary:

An appropriate monitoring regime would be developed might include the following elements:

- Operator logs of:
- Waste deliveries and analyses
- Operation of incineration plant
- Temperatures and oxygen levels
- Flow rates
- Support fuels used
- Excursions or out of specification operation
- Continuous emission monitors
- Periodic testing for some pollutants
- Transparent, traceable and auditable

APPENDIX E

Certificates of Approval / Information on Monitoring Requirements of Incineration Facilities in Canada

APPENDIX E-1

Algonquin Power Energy-From-Waste Facility, Peel Region, ON

Ministry of the Environment | Ministère de l'Environnement

Ontario

KMS Peel Inc.
7656 Bramalea Road
Brampton, Ontario
L6T 5M5

Located at: Lot 14, Concession 4
Brampton, Regional Municipality of Peel

This Certificate of Approval (Air) revokes and replaces Certificate of Approval (Air) Number 8-3170-89-916 dated April 27, 1991 and Notices of Amendment dated June 2, 1992, March 9, 1993, November 23, 1999 and July 25, 2000.

You have applied in accordance with Section 9 of the Environmental Protection Act for approval of:

an energy-from-waste facility to produce electricity utilizing municipal solid waste, containing domestic, commercial and solid non-hazardous industrial waste, as a fuel, as also approved under the Environmental Assessment Act by Order in Council dated October 4, 2000 together with Notice of Approval to Proceed with the Undertaking, EA File No. PR-KM-02, complete with the following major components:

1. five 2-stage incinerators by Consumat Systems Inc., or its successor, as described in Section 5. of Appendix A of the Application for a Certificate of Approval (Air), each having a nominal design Waste Processing Rate of 91 tonnes per day of municipal solid waste fuel, with a Waste Processing Rate range of 90 percent to 120 percent of the design Waste Processing Rate, each equipped with:

   a. a charging hopper, complete with a ram feed system;

   b. a primary combustion chamber complete with four fixed hearths, a natural gas fired Eclipse WC-6 auxiliary burner, or equivalent, rated at 527,000 kilojoules per hour, an American Fan IE-9-AH, 5 HP burner blower, or equivalent, and water sprays for cooling;

   c. an automatic residue removal ram system, complete with a water seal, a water-cooled steel jacket and an integral sump;

d. a secondary combustion chamber, complete with a natural gas fired Eclipse 3216 MVTA burner, or equivalent, rated at 10,540,000 kilojoules per hour, an American Fan IE-9-AH, 7.5 HP burner blower, or equivalent, and one Twin City Model 330 BC-SW, 60 HP, combustion air blower, or equivalent, with a normal air flow of 9.45 cubic metres per second at 65oC; and

e. one Twin City Model 919 RBO/R, 50 HP, recirculation blower, or equivalent, with a normal air flow of 3.23 cubic metres per second at 204oC;

2. five water tube, waste heat recovery boilers, by DELTAK, or equivalent, with a nominal design Steam Production Rate of 15,195 kilograms per hour at a pressure of 4,300 kilopascals and a temperature of 340oC, each complete with:

   a. a superheater;

   b. an economizer;

   c. sootblowers; and

   d. five ash collection hoppers;

3. one condensing type Westinghouse, or equivalent, steam turbine-generator set having a nominal capacity of 9,000 kilowatts;

4. one GEA-PCS air-cooled condensor, or equivalent;

5. two Air Pollution Control Trains, by Procedair Industrie, each consisting of:

   a. a vertical, downflow flue gas conditioning tower, referred to as the Evaporative Cooling Tower (ECT), having a height of 22.2 metres and a diameter of 4.2 metres, complete with a co-current water spray system, having a water rate of 55.5 litres per minute and a gas residence time of 4.7 seconds;

   b. a vertical, upflow venturi-type reactor tower, having a height of 17.0 metres and a diameter of 1.75 metres, complete with an inlet section, venturi section, a reactor column and a dry lime injection at an approximate rate of 68 kilograms per hour into the inlet section, with a gas residence time of approximately 4 seconds in the reactor column and the ductwork prior to the baghouse;

c. a baghouse, as designed by Procedair Industries, or equivalent, with the following specifications:

i. a compressed air pulse-type, on-line cleaning system;

ii. woven fiberglass filter media; and

iii. a filtering area of 2132 square metres with a normal air flow of 28.9 actual cubic metres per second at 165 oC and a filtering velocity of 1.4 centimetres per second, when all incinerators and both Air Pollution Control Trains are operating;

d. a centrifugal, backward curved single skin airfoil Flakt HACB-100-227-13, or equivalent, induced draft (ID) fan capable of operating at 1300 rpm with an air flow rate of 27.6 actual cubic metres per second at 165 oC and 4.48 kilopascals at 1185 rpm; and

e. An air sealed control valve on the discharge of the induced draft (ID) fan allowing gas to be directed either to the Bypass Stack, or to the mixing plenum of the selective catalytic reduction (SCR) reactor described in item 7 below;

6. One Mercury Control System, consisting of:

One sodium tetrasulphide injection system to supply sodium tetrasulphide into the hot gas duct ahead of the existing Evaporative Cooling Tower (ECT) to control emissions of mercury in the exhaust gases from the five Incinerators, complete with:

i. injection lances,

ii. one feed pump,

iii. two dosing pumps,

iv. one sodium tetrasulphide mixing tank having a capacity of one cubic metre and equipped with an activated carbon cartridge filter,

v. two sodium tetrasulphide storage bins, each having a capacity of one cubic metre, complete with two suction lances;

all located inside a container, equipped with a hydrogen sulphide monitor and alarm system, and

vi. One sodium tetrasulphide storage tank, having a capacity of 9.46 cubic metres;

7. One NOx and Dioxin Control System, designed by KWH, or equivalent, consisting of:

a. One selective catalytic reduction (SCR) reactor, to control emissions of nitrogen oxides and chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans in the exhaust gases from the five Incinerators, located downstream of the ID fans, complete with:

i. 18 catalyst modules, each containing 72 honeycomb patterned titanium/ vanadium oxide catalyst elements providing a total surface area of 782 square metres operated at a temperature between 260oC and 300oC;

ii. three injection lances to deliver anhydrous ammonia and air mixture into the Gas Turbine discharge duct at a rate controlled by both the nitrogen oxide analyzer located in the Main Stack and the nitrogen oxide analyzer located ahead of the Evaporative Cooling Tower (ECT); and

iii. one horizontal ammonia storage tank having a capacity of 11.365 cubic metres, located inside a fenced area adjacent to the Gas Turbine hall, complete with pressure relief valves and a pressure reducing station, designed to comply with MOL Engineering Note 4-04 covering anhydrous ammonia storage systems;

b. one Main Stack having an exit diameter of 2.3 metres extending to a height of 35.18 metres above grade located on top of the SCR reactor housing.

8. a continuous emission monitoring system including:

a. one Altech HW monitoring system, or equivalent, to measure the concentration of hydrogen chloride, nitrogen oxides, carbon monoxide and water vapour in the flue gases in the Main Stack, complete with:

i. Sample extraction system, including a heated in-stack probe and filter arrangement contained in a heated box fastened on the stack monitoring port;

ii. heated sample transfer line connecting the filter box and the heated sampling pump;

iii. heated sampling pump contained in the sampling module at ground level;

iv. Bodenseewerk Model MCS 100 analyzer, or equivalent, which is a multi-component infrared photometer using:

(i) the Gas Filter Correlation (GFC) technique for hydrogen chloride and carbon monoxide measurement, and

(ii) the Single Beam Dual Wavelength (SBDW) technique for moisture and nitrogen oxide measurement;

v. PLC - a programmable logic controller that provides control and processing for all analyzer and sample system functions, including calibrations, and self checking and alarming of system faults.

b. one Rosemount NGA2000 Heated Wet nitrogen oxide analyzer, or equivalent, installed in the hot gas ducting ahead of the ECT prior to the bypass duct leading into the Bypass Stack, to measure the nitrogen oxide concentration in the combined flue gases from the five Incinerators;

c. two dilution probe sampling systems to measure the concentrations of hydrogen chloride in the flue gases extracted at each of the exits of the two (2) baghouses, each system consisting of:

i. sample extraction system which is a dilution probe system mounted in the duct at the exit of the baghouse;

ii. freeze protected heated sample transfer line connecting the probe and the analyzer; and

iii. TECO Model 15 Gas Filter Correlation Infrared analyzer, or equivalent;

d. five TECO Model 48 Gas Filter Correlation Infrared analyzers, or equivalent, to measure concentration of carbon monoxide in the flue gases extracted by five dilution probes located at the exit of each of the five Economizers;

e. six Enviroplan Model CEMOX2 Zirconium Oxide analyzers, or equivalent, to measure the concentration of oxygen by in-situ probes located:

i. in the Main Stack; and

ii. at the exit of each of the five Economizers;

f. one Rosemount OPM 2000R Opacity Transmitter, or equivalent, located in the Main Stack;

g. one Durag Model 281 double pass opacity monitor, or equivalent, located in the Bypass Stack;

h. two Durag Model 216 double pass opacity monitors, or equivalent, located at the exit of each of the two baghouses;

i. one EMCR differential pressure flow measuring device, or equivalent, located in the Main Stack; and

j. two Chrontrol Model CD, or equivalent or better, automated calibration systems;

9. continuous process controls, including, but not limited to the following:

a. thermocouples to measure the temperature for the following:

i. primary chamber of each of the five Incinerators;

ii. secondary chamber of one of the five Incinerators at a location downstream of the last air injection ports where the combustion temperature is fully developed;

iii. outlet duct from the secondary chamber of each of the five Incinerators, at a location where a flue gas retention time of one second is achieved;

iv. flue gas at the inlet and outlet of each Boiler;

v. flue gas at the inlet and outlet of each ECT;

vi. flue gas at the inlet to each baghouse;

vii. flue gas at the entrance to the catalyst bed in the SCR reactor; and

viii. flue gas in the Main Stack and in the Bypass Stack;

b. pressure gauges to measure the static pressure at the inlet of each of the two venturi reactor towers;

c. differential pressure gauges to measure the differential pressure of each baghouse and each baghouse compartment, with the differential pressure drops for each individual compartment being field readouts, and the overall differential pressure for each baghouse being monitored through the computer-based data acquisition system; and

d. ambient air and exhaust gas temperature measurement devices, natural gas flowrate measuring device and electrical output measuring device, all for the Gas Turbine generator, described in item 12 of the preamble of this Certificate;

10. an bypass duct complete with a double bladed isolating damper, located ahead of the Air Pollution Control Trains and the NOx and Dioxin Control System, directing the flue gases from the five Incinerators into the Bypass Stack extending 35.18 metres above grade with an inside exit diameter of 1.65 metres, exhausting to the atmosphere at a normal volumetric rate of 50.25 actual cubic metres per second at 165 oC;

11. Lime storage facilities consisting of:

a. one lime feed silo, having a height of 7.1 metres, a diameter of 2.74 metres and a fill rate of 200 kilograms per minute, exhausting to the atmosphere through a Sonair Model 81024 bin vent filter, or equivalent, at a volumetric flowrate of 0.4 actual cubic metre per second at 20 oC, and,

b. One lime receiving silo designed to hold 50 tonnes of hydrated lime, equipped with a bin vent filter, with 21.7 square metres of cloth area, complete with a pulse jet cleaning system and a discharge into a shelter around the silo;

12. one air pollution control system residue silo, having a height of 6.4 metres and a diameter of 3.7 metres, exhausting to the atmosphere through a Sonair Model 81024 bin vent filter, or equivalent, at a volumetric flowrate of 0.05 actual cubic metre per second at 20 degrees Celsius;

13. One (1) Taurus 60S - T7300 in a SoLoNOx configuration, or equivalent, gas turbine generator with a nominal generating capacity of 5.2 megawatts electrical, firing natural gas at a nominal thermal input of 65.3 million kilojoules per hour and exhausting to the mixing plenum of the selective catalytic reduction system described in item 6 above at a rate of 49 actual cubic metres per second, at a temperature of 485 oC, or alternatively through a stack with an exit diameter of 1.067 metres, extending 10.97 metres above grade and 2.6 metres above the roof of a separate building adjacent to the energy from waste facility.

14. Plant Control System to control the operation of the fuel enhancement system, the Incinerators, the Boilers, the water treatment system, the air cooled condenser, the Gas Turbine and generator set, the Air Pollution Control Trains, the Mercury Control System, the NOx and Dioxin Control System, the continuous emission monitoring systems, the water supply and storage, and the air compressors, complete with a computer-based data acquisition, alarm and reporting system, including computer hardware and software capable of displaying emission data at a remote location for public information.

All in accordance with the documents listed in the attached Schedule 1.

Terms and Conditions as listed in Schedule 2.

In accordance with Section 139 of the Environmental Protection Act, R.S.O. 1990, Chapter E-19, as amended, you may by written Notice served upon me, the Environmental Appeal Board and in accordance with Section 47 of the Environmental Bill of Rights, S.O. 1993, Chapter 28, the Environmental Commissioner, within 15 days after receipt of this Notice, require a hearing by the Board. The Environmental Commissioner will place notice of your appeal on the Environmental Registry. Section 142 of the Environmental Protection Act, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the works are located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary *,
Environmental Appeal Board,
2300 Yonge St., 12th Floor,
P.O. Box 2382,
Toronto, Ontario.
M4P 1E4

The Environmental Commissioner,
1075 Bay Street,
Suite 605,
6th Floor,
Toronto, Ontario.
M5S 2B1

The Director,
Section 9, *Environmental Protection Act*,
Ministry of the Environment,
2 St. Clair Avenue West, 12A Floor,
Toronto, Ontario.
M4V 1L5

* *Further information on the Environmental Appeal Board's requirements for an appeal can be obtained directly from the Board by: Tel: (416) 314-4600, Fax: (416) 314-4506 or Web Site: www.ert.gov.on.ca*

This instrument is subject to Section 38 of the Environmental Bill of Rights, that allows residents of Ontario to seek leave to appeal the decision on this instrument. Residents of Ontario may seek to appeal within 15 days from the date this decision is placed on the Environmental Registry. By accessing the Environmental Registry, you can determine when the leave to appeal period ends.
The above noted works are approved under Section 9 of the Environmental Protection Act.

DATED AT TORONTO this 14th *day of* February,2001.

for S. Klose, P.Eng.,
Director,
Section 9,
Environmental Protection Act.

Encls.

cc: J. Budz, District Manager, Halton-Peel District Office
Richard Brown, Business & Fiscal Planning Branch
Director, Environmental Monitoring and Reporting Branch
Clerk, The City of Brampton
Clerk, The Regional Municipality of Peel

SCHEDULE 1

This Schedule 1 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, Dated February 14, 2001

LIST OF DOCUMENTS

1. Reasons for Decision and Decision, Proposed Energy From Waste Facility, An Undertaking by SNC Inc. in the Regional Municipality of Peel, The Consolidated Hearings Act, 1981, The Joint Board, dated October 24, 1988.

2. Application for a Certificate of Approval (Air), dated June 20, 1989, and all supporting documentation.

3. A document entitled "Air Pollution Control System Design Description, Description No. 3884-0000-40EC-04.", dated February 9, 1990.

4. Application for a Certificate of Approval (Air), dated January 11, 1993, signed by John Pappain, and all supporting material).

5. Application for a Certificate of Approval (Air), dated September 22, 1999, signed by John Pappain, and all supporting material).

6. Application for a Certificate of Approval (Air), dated September 11, 2000, signed by John Pappain, and all supporting material.

7. Memorandum from John Chandler, A.J. Chandler & Associates Ltd., on behalf of KMS Peel Inc., dated January 22, 2001.

8. Memorandum from John Chandler, A.J. Chandler & Associates Ltd., on behalf of KMS Peel Inc., dated February 6, 2001.

SCHEDULE 2

This Schedule 2 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, Dated February 14, 2001

SPECIAL TERMS AND CONDITIONS

SECTION 1 GENERAL

DEFINITIONS

1. For the purpose of this Certificate of Approval:

(1) "Act" means the Environmental Protection Act, R.S.O. 1990, C. E-19 as amended;

(2) "Air Pollution Control Train" means one of the two systems that include a gas conditioning tower, referred to as the Evaporative Cooling Tower (ECT), venturi reactor tower with lime injection and a baghouse, all as described in item 5 of the preamble of this Certificate;

(3) "Appeal Board" means the Environmental Appeal Board;

(4) "Board" means the Joint Board pursuant to the Consolidated Hearings Act, 1981, associated with the Provisional Certificate of Approval Waste Disposal Site Number A 220216, including all conditions on that approval;

(5) "Boiler" means any one of the five waste heat recovery boilers described in item 2 of the preamble to this Certificate;

(6) "Bypass Stack" means the alternate stack that may be used either during the time when the NO_x and Dioxin Control System is off-line or in emergency situations when it is necessary to discharge emissions that have not been controlled by the Mercury Control System, the Air Pollution Control Trains and the NO_x and Dioxin Control System;

(7) "Certificate" means this Certificate of Approval (Air), and Schedules 1-17, all as may be amended from time to time;

(8) "Commencement Date of Operation" means the date when waste is first fed into all five Incinerators;

(9) "Company" means KMS Peel Inc. and includes its successors and

assignees;

(10) "Continuous Emission Monitoring System" means all of the items described in item 8 of the preamble of this Certificate;

(11) "Continuous Process Control System" means all of the items described in items 9 and 14 of the preamble of this Certificate;

(12) "Controlled Shutdown" means an immediate cut-off of all waste and waste derived fuel into the primary chamber, while maintaining the operation of the secondary chamber and the Air Pollution Control Trains within the Performance Conditions;

(13) "Dioxins" means polychlorinated dibenzo-p-dioxins;

(14) "Director" means the Director of the Environmental Assessment and Approvals Branch of the Ministry, or successor;

(15) "District Manager" means the District Manager of the Halton-Peel District Office of the Ministry, or successor;

(14) "Economizer" means one of the five economizers listed in item 2 of the preamble of this Certificate;

(16) "ECT" means the vertical, downflow flue gas conditioning tower described in item 5 of the preamble of this Certificate;

(17) "Emergency Shutdown" means an immediate cut-off of all waste and waste derived fuel into the primary chamber, followed by an accelerated extinction of all combustion in the primary chamber by means of water sprays, while maintaining the secondary chamber temperature within the Performance Conditions, except when unreasonable;

(18) "Facilities" means the entire energy-from-waste facility, including, but not limited to the major components as listed in the preamble of this Certificate, and all fixtures, appurtenances and equipment;

(19) "40 CFR 60" means title 40, part 60 under the Code of Federal Regulations (Air Programs, U.S. Environmental Protection Agency), revised as of July 1, 1990, published by the Office of the Federal Register, National Archives and Records, Administration in the United States of America;

(20) "Furans" means polychlorinated dibenzofurans;

(21) "Gas Turbine" means the natural gas fired combustion turbine described in item 13 of the preamble of this certificate;

(22) "Incinerator" means any one of the five two-stage thermal destruction units described in item 1 of the preamble of this Certificate;

(23) "Independent Acoustical Consultant" means an Acoustical Consultant not representing the Company, and not involved in the noise impact assessment or the design/implementation of noise control measures for the Facilities and not retained by the consultant involved in the noise/vibration impact assessment or the design/implementation of noise/vibration control measures for the Facilities;

(24) "Main Stack" means the stack that discharges emissions from the five Incinerators after those emissions have been controlled by the Mercury Control System, the Air Pollution Control Trains and the NO_x and Dioxin Control System, as described in items 5, 6 and 7 of the preamble of this Certificate;

(25) "Manager" means the Manager, Technology Standards Section, Standards Development Branch of the Minsitry, or any other person who represents and carries out the duties of the Manager, as those duties relate to the conditions of this Certificate, or successor;

(26) "Mercury Control System" means a sodium tetrasulphide injection system as described in item 6 of the preamble of this Certificate;

(27) "Ministry" means the Ontario Ministry of the Environment;

(28) "NO_x and Dioxin Control System" means the equipment associated with and the selective catalytic reduction (SCR) reactor described in item 7 of the preamble of this Certificate;

(29) "Operating window" means a compilation of operational parameters that constitute normal operation within the Performance Conditions, including but not limited to the upper and lower limits for:

(a) the primary and secondary chamber temperatures;

(b) the oxygen and carbon monoxide concentrations at the outlet of the secondary chamber of each of the five Incinerators;

(c) the inlet and outlet temperatures for each of the five waste heat boilers, each of the two conditioning towers, each of the two venturi dry lime reactors;

(d) the water spray rate into each of the two flue gas conditioning towers;

(e) the lime feed rate into each of the two venturi dry lime reactors;

(f) the pressure drop across each of the two venturi throats;

(g) the inlet temperature for each of the two baghouses;

(h) the differential pressure for each of the two baghouses;

(i) the sodium tetrasulphide feed rate to the injection lances;

(j) the ammonia feed rate to the turbine exhaust gas stream;

(k) the differential pressure across the SCR catalyst bed; and

(l) the inlet gas temperature to the SCR catalyst bed;

(30) "Performance Conditions" means conditions set out Section 2 in this Schedule 2;

(31) "Proceedings" means the proceedings before the Joint Board;

(32) "Provisional Certificate" means the corresponing **Provisional Certificate of Approval Waste Disposal Site,** including all conditions on that approval, issued to cover the Site, as may be amended and/ or replaced from time to time;

(33) "Publication NPC-103" means Publication NPC-103 of the Model Municipal Noise Control By-Law, Final Report, August 1978, as amended;

(34) "Publication NPC-205" means the Ministry Publication NPC-205, Sound Level Limits for Stationary Sources in Class 1 & 2 Areas (Urban), October 1995;

(35) "Publication NPC-233" means the Ministry Publication NPC-233, Information to be Submitted for Approval of Stationary Sources of Sound, October 1995;

(36) "Regional Director" means the Regional Director of the Central Region of the Ministry;

(37) "Regulation" means Ontario Regulation 346 enacted under the Environmental Protection Act;

(38) "Report EPS 1/PG/7" means Environment Canada Report EPS 1/PG/7, "Protocols and Performance Specifications for

Continuous Monitoring of Gaseous Emissions from Thermal Generation", September, 1993;

(39) "SCR reactor" means the selective catalytic reduction reactor described in item 7 in the preamble of this Certificate;

(40) "Site" means the property, where the Company has located and operates the Facilities;

(41) "Soil Sampling" means sampling and analyzing of soil to determine the accumulation of contaminants in the neighbouring soil resulting from the operation of the Facilities;

(42) "Source Testing" means means sampling and testing to measure emissions resulting from operating the Incinerators within the proposed or existing Operating Window of the Incinerators as required in Section 4 of this Schedule 2;

(43) "Source Testing Code" means the Ontario Source Testing Code, Version #2, Report # ARB-66-80, November 1980;

(44) "Steam Production Rate" means the mass of steam per unit of time generated by a Boiler utilizing the heat content of the flue gases from any of the five Incinerators;

(45) "Total Power Failure" means the loss of the external power supply and concomitant loss of all in-plant power generation;

(46) "Undiluted Gases" means the flue gas stream which contains oxygen, carbon monoxide, total hydrocarbons and all contaminants in the same concentrations as they exist in the flue gas stream emerging from an individual piece of equipment, such as the secondary chamber of one Incinerator or one baghouse, and into which gas stream no ambient air and/or no other gas stream originating from another piece of equipment, except for dilution air introduced within the Continuous Emission Monitoring Systems, has been introduced; and

(47) "Waste Processing Rate" means the mass of waste fed into one of the five Incinerators per unit of time.

<u>SCOPE OF APPROVAL GRANTED</u>

2. (1) The approval is granted by this Certificate under Section 9 of the Act, and permits the Company to proceed with the proposed construction of the Facilities, subject to the conditions imposed herein, and is based upon a review of the proposed construction only in the context of its effect on the environment, its process performance and good engineering practise.

(2) The review did not include a consideration of the architectural, mechanical, structural, electrical or instrumentational components of the Facilities, except to the extent necessary to review the proposal as set out in subsection (1).

(3) The issuance of this Certificate in no way abrogates the Company's legal obligations to take all reasonable steps to avoid violating other applicable provisions of this legislation and other legislation and regulations.

INTERPRETATION (Severability and Conflicts)

3. (1) The requirements of this Certificate are severable. If any requirement of this Certificate, or the application of any requirement of this Certificate to any circumstance, is held invalid, the application of such requirement to other circumstances and the remainder of this Certificate shall not be affected thereby.

(2) In all matters requiring the interpretation and implementation of this Certificate, the conditions of the Certificate shall take precedence, followed in descending order by the Board's decision, Company's application for this Certificate and the documentation, referred to in this Certificate and submitted in support of the application for this Certificate.

CONSTRUCTION CHANGES

4. (1) For the purposes of this section, "effect on the Facilities" means any potential effect upon the operation and/or performance of the Facilities or the characteristics, rate or manner of discharge of any contaminant from the Facilities.

(2) The Company shall ensure that no changes in the construction/design of the Facilities, resulting from unforeseen construction problems and capable of producing an effect on the Facilities, are made unless and until the Company applies for and receives a written approval of the Director pursuant to Section 9 of the Act, except when specifically allowed by subsection 9(6) of the Act.

COMPLIANCE

5. (1) The Company shall ensure compliance with all the terms and conditions of this Certificate and the Provisional Certificate, when the Facilities are operating. Non-compliance constitutes a violation of the Act and is grounds for enforcement.

(2) The terms and conditions of this Certificate and the Provisional Certificate are minimum requirements, and the Company shall, in addition to the specific requirements on this Certificate, operate and maintain the Facilities in accordance with good engineering practise and in such a way that emissions to the natural environment are minimized to the lowest level possible, at all times.

(3) The issuance of and the Company's compliance with this Certificate in no way abrogate the Company's liability to prosecution by the Ministry, in the event that the Company causes an adverse effect and/or does not comply with the Act, the Regulation and/or conditions on this Certificate.

INFORMATION

6. (1) The Company shall, forthwith upon request of the Director, Regional Director, District Manager, any Ministry employee representing any of the above persons, a provincial officer, or any of them, furnish any information requested concerning compliance with this certificate, including but not limited to any records required to be kept by this certificate.

(2) In the event that the Company provides to the Ministry information, records, documentation or notification in accordance with this certificate (for the purposes of this Condition, "information"),

(a) the receipt of said information by the Ministry;

(b) the acceptance by the Ministry of the information's completeness or accuracy; or,

(c) the failure of the Ministry to take any action in relation to said information;

shall not be construed as approving, excusing or justifying any act or omission of the Company relating to or revealed by the said information.

CHANGE OF OWNER

7. (1) The Company shall notify the District Manager in writing of any of the following changes within 30 days of the change occurring:

(a) change of owner or operating authority, or both;

(b) change of address of owner or operating authority or address of new owner or operating authority;

(c) change of partners where the owner or operating authority is or at any time becomes a partnership, and a copy of the most recent declaration filed under the Partnerships Registration Act shall be included in the notification to the District Manager;

(d) change of name of the corporation where the owner or operator is or at any time becomes a corporation, in which case a copy of the most current "Initial Notice or Notice of Change" (Form 1, 2 or 3 of O.Reg. 189, R.R.O. 1980, as amended from time to time), filed under the Corporations Information Act, shall be included in the notification to the District Manager;

(2) When the ownership of the Site and/or Facilities changes, the Company shall notify in writing the succeeding owner of the existence of this Certificate, and the Company shall forward a copy of such notice to the District Manager.

(3) The Company shall ensure that all communications made pursuant to this condition will refer to this Certificate's number.

SECTION 2 PERFORMANCE CONDITIONS

DESIGN REQUIREMENTS

8. The Company shall have the Facilities designed in such a manner as to ensure that each of the five Incinerators is capable of maintaining, on a continuous basis, a temperature of not less than 1100°C in the secondary chamber of the Incinerator.

9. The Company shall have the Facilities designed and operated in such a manner as to ensure that the following Performance Conditions are met at all times:

(1) Each Incinerator shall be capable of regulating, by means of auxiliary fuel control, the temperature at the outlet of the secondary chamber, so as to ensure that a temperature of not less than 1000°C is attained prior to introduction of waste or waste derived fuel into the primary chamber during the start-up, and thereafter maintained during the entire incineration cycle and subsequent shutdown until all waste combustion is completed in the primary chamber, and until the final ash is discharged from the primary chamber.

(2) Each Incinerator shall include primary and secondary air control systems, which are capable of automatically adjusting the distribution and the quantity of combustion air, in such a manner that changes in the Waste Processing Rate and/or waste composition or irregularities in the loading and/or combustion shall not adversely affect the performance of the Incinerator.

(3) The residence time for the combustion gases in the secondary chamber of each of the five Incinerators shall be a minimum of one second at a temperature of 1000°C, and shall be calculated from the point where most of the combustion has been completed and the incineration temperature fully developed, to the last thermocouple, where the temperature of not less than 1000°C is maintained.

(4) The Incinerators shall provide and maintain a high degree of gas turbulence and mixing in the secondary combustion chamber.

(5) The Incinerators shall achieve the temperature, residence time, oxygen availability and turbulence requirements over the complete range of operating parameters, including feed rate, feed characteristics, combustion air, flue gas flow rate and heat losses.

(6) The inlet temperature into each baghouse shall be not less than 120°C and not more than 185°C.

<u>STACK/FLUE CONCENTRATION LIMITS</u>

10. The Company shall, at all times, operate the Facilities in such a manner as to ensure that the following Performance Conditions are met:

(1) The concentration of organic matter having a carbon content, expressed as equivalent methane, in the Undiluted Gases at the outlet of the secondary chamber of each of the five Incinerators and being an average of ten measurements taken at approximately one minute intervals, shall be not more than 50 parts per million by volume on dry basis.

49 mg/ = 42.5 ppm

ppm = M

(2) The 4-hour average concentration of carbon monoxide in the Undiluted Gases at the outlet of the secondary chamber of each of the five Incinerators shall be not more than 35 parts per million by volume on dry basis normalized to 11 percent oxygen at a reference temperature of 25°C and a reference pressure of 101.3 kilopascals, and 49 milligrams per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25°C and a reference pressure of 101.3 kilopascals as measures in the Main Stack.

(3) The residual oxygen, calculated as a 4-hour average concentration, in the Undiluted Gases at the outlet of the secondary chamber of each Incinerator shall be not less than 6 percent by volume on dry basis.

(4) (a) The 24-hour average concentration of hydrogen chloride in the Undiluted Gases at the outlet of each of the two Air Pollution Control Trains and in the Bypass Stack, should it be in operation, shall be not more than 18 parts per million by volume on dry basis, or 27 milligrams per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25°C and a reference pressure of 101.3 kilopascals; or

(b) The 24-hour average concentration of hydrogen chloride in the Main Stack shall be not more than 15 parts per million by volume on dry basis, or 22 milligrams per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25°C and a reference pressure of 101.3 kilopascals when the Gas Turbine is operating.

(5) The concentration of suspended particulate matter in the Main Stack shall be not more than 14 milligrams per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25°C and a reference pressure of 101.3 kilopascals when the Gas Turbine is operating.

(6) The opacity of the gases at the outlet duct of each of the two Air Pollution Control Trains and in the Main Stack, shall be not more than:

(a) 5 percent, calculated as a 2-hour average; and,

(b) 10 percent, calculated as a 6-minute average.

(7) (a) The toxic equivalent concentration of Dioxins and Furans in the Main Stack shall be not more than 70 picograms per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25°C and a reference pressure of 101.3 kilopascals when the Gas Turbine is operating.

(b) The toxic equivalent concentration of Dioxins and Furans shall be calculated in accordance with the International Scheme set out in Schedule 3 of the Certificate.

(8) The 24-hour average concentration of oxides of nitrogen in the Main Stack shall be not more than 94 parts per million volume on a dry basis or 177 milligrams per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25°C and a reference pressure of 101.3 kilopascals when the Gas Turbine is operating.

(9) The concentration of mercury in the Main Stack shall be not more than 17 micrograms per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25°C and a reference pressure of 101.3 kilopascals when the Gas Turbine is operating.

(10) The concentration of cadmium in the Main Stack shall be not more than 12 micrograms per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25°C and a reference pressure of 101.3 kilopascals when the Gas Turbine is operating.

(11) The concentration of lead in the Main Stack shall be not more than 120 micrograms per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25°C and a reference pressure of 101.3 kilopascals when the Gas Turbine is operating.

ADDITIONAL POINT IMPINGEMENT CONCENTRATIONS

11. The Company shall, at all times, operate the Facilities in such a manner as to ensure that the following Performance Conditions are met:

(a) The maximum concentration of a contaminant set out in Column 1 of the Table in Schedule 4, at a point of impingement from a source of contaminant shall not be greater than the concentration set out opposite thereto in Column 3 of the Table in Schedule 4, expressed in the unit of concentration set out opposite thereto in Column 2 of the Table in Schedule 4.

(b) The concentration of a contaminant at a point of impingement may be calculated in accordance with the Appendix to the Regulation.

DETERMINATION OF COMPLIANCE WITH PERFORMANCE CONDITIONS

12. The Company shall install a thermocouple, referred to as an upstream thermocouple, in the secondary chamber of one of the five Incinerators, at a location downstream of the last row of air injection ports, where the combustion temperature is fully developed, to measure and indicate the temperature at the point, from which the volume for retention time calculations begins.

13. The Company shall install continuous moisture monitors in the following locations:

    (1) in the combined flue gas duct for the five Incinerators; and

    (2) in the Main Stack.

14. Compliance with the Performance Conditions in this Certificate shall be determined as follows:

    (1) For carbon monoxide, oxygen, hydrogen chloride, oxides of nitrogen, opacity, secondary chamber temperature and baghouse inlet temperature, ~~as well as Gas Turbine operation,~~ the records of the continuous monitoring systems, as converted to dry basis using the records of the continuous moisture monitors, provided that all continuous monitors are operating within the Design and Performance Specifications, set out in the attached Schedules 5-11, shall be considered to be the true records of the actual emissions and/or conditions, and shall be required to comply with the limits set out in the relevant Performance Conditions;

    (2) the flue gas retention time in the secondary chamber of each of the five Incinerators shall be deemed to be in compliance with the relevant Performance Condition, if the upstream thermocouple, all thermocouples in the secondary chamber downstream of the last row of the air injection ports in each of the five Incinerators, and the downstream thermocouples in the outlet duct of the secondary chamber of each of the five Incinerators indicate that a minimum temperature of 1000°C has been reached; and

    (3) for organic matter, suspended particulate matter, Dioxins and Furans, mercury, lead and cadmium and any other contaminants measured during the Source Testing, the results of the Source Testing shall be required to comply with the Regulation and the relevant Performance Conditions.

15. The Company may install the continuous emission monitors at such locations where the monitored parameter levels reasonably represent the actual parameter levels at the locations referred to in the Performance Conditions.

NOISE EMISSION LIMITS

16. The Company shall ensure that the noise emissions from the Facilities comply with the limits set in accordance with Ministry Publication NPC-205.

SECTION 3 OPERATION AND MAINTENANCE OF THE FACILITIES

Waste Processing Rate

17. The Company shall ensure that, at all times, waste is fed into the Incinerators at such a rate that the total Steam Production Rate for the Facilities does not exceed 110 percent of the Steam Production Rate for the five Incinerators achieved during the previous successful annual Source Testing program and that waste is fed into each of the five Incinerators at such a rate that the Steam Production Rate for any of the five Boilers does not exceed 110 percent of the Steam Production Rate for a single Boiler achieved during the previous successful annual test program. Under no circumstances shall the Steam Production Rate for a single Boiler exceed 14,500 kilograms per hour, calculated as a 24-hour average.

GENERAL OPERATION AND MAINTENANCE

18. (1) The Company shall establish an Operating Window for the Facilities, including all set points for the continuously monitored parameters, during the first Source Testing campaign following the Commencement Date of Operation, and shall submit the Operating Window to the Director, Manager and the District Manager as part of the Source Testing Report.

(2) The Company shall then, at all times, operate the Facilities within the proposed Operating Window, unless and until the Regional Director determines that the proposed Operating Window will not, based on the Source Testing results, adequately guarantee compliance with the Act, the Regulation and the Performance Conditions of this Certificate.

(3) The Company shall operate the Incinerators with:

(a) one Air Pollution Control Train controlling emissions when the total Waste Processing Rate into any number of the five Incinerators is less than 60 percent of the maximum, total design Waste Processing Rate into all five Incinerators;

(b) two Air Pollution Control Trains when the total Waste Processing Rate into any number of the five Incinerators is greater than 60 percent of the maximum, total design Waste Processing Rate into all five Incinerators.

19. (1) The Company shall ensure that, at all times, the Facilities, including all related fixtures, appurtenances, equipment and services, which are installed or used to achieve compliance with this Certificate are operated and maintained in accordance with good engineering practises and the Manufacturers' recommendations.

(2) In addition, the Company shall ensure that:

(a) funding, staffing, training of staff, process controls, quality assurance and quality control procedures of or in relation to the Site and the Facilities are adequate to achieve compliance with this Certificate; and,

(b) equipment, material and spare parts, of equal or better quality and specifications, are kept on hand and in good repair for immediate use in the event of:

(i) a breakdown of the Facilities or any part of the Facilities;

(ii) any change in process parameters which may result in a discharge into the natural environment of any contaminant in an amount, concentration or level in excess of that prescribed by the Regulation and/or imposed by this Certificate of approval;

(iii) any fire or explosion;

(iv) any spill within the meaning of Part X of the Act; and

(v) any other potential contingency,

and staff are trained in the use of said equipment, material and spare parts and in the methods and procedures to be employed upon the occurrence of such an event.

OPERATIONS MANUAL

20. (1) The Company shall prepare and periodically update an operations manual for the Facilities, ~~including the Gas Turbine~~, and make the said manual available for inspection by staff of the Ministry at any time when Facilities are operated.

(3) The Company shall ensure that the operations manual includes as a minimum:

(a) a staffing plan;

(b) a training program, including personal safety;

(c) operating procedures for routine operation, complete with all set points and normal operating ranges for continuous process and emission monitoring and control systems, including the normal ranges for the Operating Window, which are to be finalized during the first Source Testing following the Commencement Date of Operation;

(d) inspection programs, including frequency of inspection, and the methods or tests employed to detect when maintenance is necessary;

(e) repair and maintenance programs, including the frequency of repair and maintenance;

(f) any other plans and procedures which are necessary because of the special nature of the Facilities, the materials used in the Facilities, or the location thereof;

(g) complaint handling procedures;

(h) a list of personnel positions responsible for operation and maintenance, including supervisory personnel and personnel responsible for recording and reporting pursuant to the requirements of this Certificate, along with the training and experience required for the positions and a description of the responsibilities;

(i) contingency plans and procedures identifying all reasonably forseeable scenarios involving a breakdown of the Facilities or a spill within the meaning of Part X of the Act and setting out how those scenarios will be dealt with to prevent or minimize the discharge of any contaminant into the natural environment, including:

(i) a list of equipment, material and personnel that will be available at the Site or will be called to the Site to deal with said contingencies;

(ii) a description of methods and procedures to be employed in dealing with said contingencies; and

(iii) the procedures to be used to forthwith notify the Ministry and, where relevant, municipal authorities, of the existence of the contingency as well as the measures being taken and proposed to deal with the contingency;

(iv) a closure plan.

(4) The Company shall:

(a) operate the Facilities, at all times, in accordance with all procedures and recommendations of the most current version of the operations manual, as submitted or as amended upon request of the Regional Director;

(b) record all inspections, repairs and maintenance carried out at the Site.

VISUAL AND AUDIBLE ALARMS

21. (1) The Company shall install and maintain visual and audible alarm systems, including, but not limited to the following:

(a) waste material silo level high;

(b) waste material handling system failure;

(c) primary chamber temperature high;

(d) secondary chamber temperature below 1000°C;

(e) boiler water level low;

(f) flue gas temperature at the inlet of either of the two baghouses low;

(g) flue gas temperature at the inlet of either of the two baghouses above 185°C;

(h) differential pressure for either of the two baghouses high;

(i) baghouse collecting hopper level high;

(j) reagent storage vessels reagent level low;

(k) reagent feed system failure;

(l) compressor trip;

(m) compressed air pressure low;

(n) 2-hour average opacity above 5 percent, or 6-minute average opacity above 10 percent, pursuant to the relevant Performance Condition;

(o) 24-hour average concentration of hydrogen chloride above the compliance value, pursuant to the relevant Performance Condition;

(p) 4-hour average concentration of carbon monoxide above 35 parts per million by dry volume at reference conditions, pursuant to the relevant Performance Condition;

(q) 4-hour average oxygen level below 6 percent by dry volume at reference conditions, pursuant to the relevant Performance Condition;

(r) 24-hour average concentration of oxides of nitrogen above 94 parts per million by dry volume at reference conditions, pursuant to the relevant Performance Condition;

(s) 24-hour average hourly Steam Production Rate high;

(t) any Plant Control System (PCS) failure.

(2) The set points for those parameters, for which this Certificate does not stipulate any value, shall be established not later than during the first Source Testing campaign following the Commencement Date of Operation.

<u>ACTION WHEN NON-COMPLIANCE OCCURS</u>

22. If any of the Continuous Emission Monitoring Systems indicates that any of the Performance Conditions are not complied with, the Company shall forthwith take all reasonable action to bring the Facilities into compliance with all Performance Conditions.

WASTE PROCESSING RATE REDUCTION

23. In the event that the Gas Turbine is taken off-line for service, waste feed shall be reduced to the equivalent of 80 percent of the maximum, total design Waste Processing Rate into all five Incinerators.

24. In the event that the SCR reactor is taken off-line for service, waste feed shall be reduced to the equivalent of 80 percent of the maximum, total design Waste Processing Rate for all five Incinerators and exhaust gas will be vented through the Bypass Stack.

25. In addition, if the Continuous Emission Monitoring System indicates that either of the Air Pollution Control Trains has been out of compliance with the Performance Condition for hydrogen chloride for a continuous 72-hour period, the Company shall forthwith reduce the Waste Processing Rate for the Incinerators by not less than 10 percent by weight from the average Waste Processing Rate for the Incinerators during the 2 hours immediately before the exceedance.

26. In addition, if the Continuous Emission Monitoring System indicates that the NO_x and Dioxin Control System has been out of compliance with the Performance Condition for oxides of nitrogen for a continuous 48-hour period, the Company shall forthwith reduce the Waste Processing Rate for the Incinerators by not less than 10 percent by weight from the average Waste Processing Rate for the Incinerators during the 2 hours immediately before the exceedance.

27. In addition, if the Continuous Emission Monitoring System indicates that any of the Incinerators has been out of compliance with the Performance Conditions for the secondary chamber temperature and carbon monoxide concentration for a continuous 8-hour period, the Company shall forthwith reduce the Waste Processing Rate for those Incinerators that are indicated to be out of compliance by not less than 10 percent by weight from the average Waste Processing Rate for the affected Incinerators during the 2 hours immediately before the upset condition.

28. In addition, if the Continuous Emission Monitoring System indicates that either of the Air Pollution Control Trains has been out of compliance with the Performance Condition for opacity for a continuous 8-hour period, the Company shall forthwith reduce the Waste Processing Rate for the Incinerators by not less than 10 percent by weight from the average Waste Processing Rate for the Incinerators during the 2 hours immediately before the upset condition and proceed to investigate whether or not maintenance to the Air Pollution Control Train is required.

WASTE FEED CUT-OFF

29. In addition, if the Continuous Emission Monitoring System indicates that the Facilities have continued to be out of compliance with the Performance Condition for hydrogen chloride for a continuous 96-hour period after the reduction of the Waste Processing Rate, the Company shall forthwith initiate a Controlled Shutdown.

30. In addition, if the Continuous Emission Monitoring System indicates that the Facilities have continued to be out of compliance with the Performance Condition for oxides of nitrogen for a continuous 32-hour period after the reduction of the Waste Processing Rate, the Company shall not operate more than four out the five Incinerators until such time that compliance with the said Performance Condition has been re-established.

31. In addition, if the continuous monitoring system indicates that the Facilities have continued to be out of compliance with the Performance Conditions for secondary chamber temperature, carbon monoxide and opacity, for a continuous 16-hour period after the reduction of the Waste Processing Rate, the Company shall forthwith initiate a Controlled Shutdown of the non-compliant Incinerator.

AIR POLLUTION CONTROL FAILURE

32. (1) In the event that one of the two Air Pollution Control Trains breaks down and/ or malfunctions, the Company shall forthwith divert all flue gases into the other Air Pollution Control Train and reduce the Waste Processing Rate for the five Incinerators in such a way that the overall Waste Processing Rate for all operating Incinerators is not more than 60 percent of the maximum design Waste Processing Rate for all five Incinerators, and shall continue to operate the Facilities at this reduced Waste Processing Rate until both Air Pollution Control Trains are in normal service.

(2) In the event that both Air Pollution Control Trains fail and/or malfunction, the Company shall forthwith cut-off all waste feed into all five Incinerators and initiate an Emergency Shutdown, while maintaining a secondary chamber temperature of 1000°C.

33. (1) The Company shall forthwith make all necessary repairs and carry out maintenance to an Air Pollution Control Train and associated equipment and instrumentation, in the event that this Air Pollution Control Train is taken out of service due to any malfunction and/or partial or complete breakdown of the Air Pollution Control Train.

(2) In the event that the Company is not able to repair and return a malfunctioning or failed Air Pollution Control Train to normal service within 10 working days of the malfunction or failure having occurred and the incineration has been continued, the Company shall forthwith, in the morning of the eleventh working day following the malfunction or failure, initiate a Controlled Shutdown of all Incinerators, unless the Regional Director has approved the continued operation.

(3) The Incinerators shall then remain shutdown, until both Air Pollution Control Trains are fully repaired and ready for normal service.

(4) If, due to unforeseen circumstances, the repair work on an Air Pollution Control Train is delayed, the Company may submit a written request to the Regional Director in order to continue operating the Facilities past the tenth day following the malfunction or failure. When making the request the Company must:

(a) demonstrate that it has exercised due diligence by maintaining an adequate spare parts inventory;

(b) provide documentation that indicates the reason for delayed repair work; and

(c) provide a date when the Air Pollution Control Train may reasonably be expected to be returned to service.

(5) The Regional Director may, after receiving the request, pursuant to subsection (4), and after considering the previous plant performance, approve, for a specified period of time, the continued operation with only one Air Pollution Control Train in service.

<u>POWER FAILURE</u>

34. (1) Upon the reduction, loss or failure of the external power source to the Facilities, the Company shall forthwith, in order to maintain compliance with the Performance Conditions of this Certificate, take all reasonable steps to minimize all discharges from the Facilities, including steps to switch to the internal plant power supply and/or to control, reduce or halt combustion and energy production.

(2) Despite subsection (1), the Company shall forthwith proceed to an Emergency Shutdown, in the event that:

(a) the loss or failure of the external power supply, pursuant to subsection (1), occurs at a time when the plant steam turbine generator is out of service for maintenance; or

(b) the plant steam turbine generator malfunctions or fails during the loss or failure of the external power source.

USE OF BYPASS STACK

35. (1) The Company shall not use the emergency bypass vent which will discharge through the Bypass Stack, except on a short term basis during the following conditions:

(a) start-up of Facilities, when no waste material has been fed into any of the five Incinerators;

(b) Total Power Failure at the Facilities;

(c) breakdown of both Air Pollution Control Trains; and/or

(d) SCR reactor out of service.

(2) When use of the emergency bypass vent is necessary due to Total Power Failure or breakdown of both Air Pollution Control Trains, the Company shall forthwith cut off all waste feed, and bring the Incinerators to an Emergency Shutdown, while maintaining, when reasonable, the secondary chamber temperature at 1000°C by burning natural gas only, until all waste is completely incinerated and the residue discharged from the primary chamber.

STEAM BLOW DOWN

2. The Company shall restrict the operation of the steam discharge to a maximum flow of 20,000 kilograms per hour and one minute duration of the controlled blow-down event in any hour, during the day-time hours from 7:00 am to 7:00 pm.

SECTION 4 MONITORING AND RECORDING

SOURCE TESTING

GENERAL

36. (1) The Company shall carry out Source Testing on the emissions from the Main Stack in accordance with the Ontario Source Testing Code, or its equivalent, as agreed upon in writing between the Company and the Manager.

(2) The Company shall submit a detailed test protocol for each sampling campaign, including duration of sampling and selection of sampling locations as well as sampling and analytical methods, to the Manager not less than six weeks prior to the planned Source Testing.

(3) The Company shall not establish a date for Source Testing until the Company has obtained the Manager's written acceptance of the finalized test protocol.

37. (1) The Company shall notify the District Manager and the Manager in writing of the location, date and time of the impending Source Testing, making reference to this Certificate, at least 30 days prior to carrying out the Source Testing; and

(2) the Manager may witness part or all of the Source Testing.

WHEN SOURCE TESTING REQUIRED

38. The Source Testing shall include the following tests:

(1) the first sampling campaign for all test parameters, as listed in Schedules 3, 12, 13, 14 and 15, within six months of the Commencement Date of Operation;

(2) subsequent annual sampling campaigns for all test parameters, as listed in Schedules 3, 12, 13 and 14, at least once during each year of operation.

COMPLIANCE TESTING

39. (1) Each sampling campaign, shall be considered to be a compliance test as defined in the Source Testing Code;

(2) each sampling campaign may include more than one test set, as separately stipulated in this Certificate or any subsequent Notice issued by the Director; and

(3) each test set shall consist of three separate tests for each contaminant to be tested.

CALCULATION OF DIOXIN AND FURAN RESULTS

40. Where the analytical results indicate that the amount of a particular isomer of Dioxins or Furans, referenced in the attached Schedule 3, is less than the detection limit reported by the laboratory analyzing the Source Testing samples the Company shall determine the amount of Dioxins and Furans to be reported as the toxic equivalent concentration by using the reported detection limit as the amount present for that isomer. The reported detection limits are to be determined by the laboratory at the time the Source Testing samples are analyzed based on analysis of appropriate replicate low level samples or blanks.

REGIONAL DIRECTOR MAY NOT ACCEPT TEST RESULTS

41. The Regional Director may not accept the results of a Source Testing, and may require that a Source Testing be repeated, if:

(1) the consultation and acceptance of the Manager did not take place; or

(2) the Source Testing Code and/or the instructions of the Manager, either during the pretest consultation or during the witnessing of the Source Testing, were not followed;

(3) the Company did not provide notification of the upcoming Source Testing; or

(4) the Company failed to provide a detailed Source Testing Report.

<u>CONTINUOUS MONITORING</u>

SELECTION, INSTALLATION AND VERIFICATION

42. (1) The Company shall select, install and test each continuous emission and/or process monitoring system in accordance with the attached Schedules 5-11.

(2) The testing, pursuant to subsection (1), shall be conducted prior to the Source Testing.

QUALITY ASSURANCE PROCEDURES

43. (1) The Company shall maintain and calibrate all Continuous Emission Monitoring Systems in accordance with the written Manufacturer's and/or Supplier's specifications and good engineering practise.

(2) In addition, the Company shall develop and conduct quality assurance procedures in accordance with 40 CFR 60, Appendix F or Report EPS 1/PG/7, as appropriate.

ACOUSTIC AUDIT MEASUREMENTS

44. The Company shall carry out acoustic audit measurements within thirty days of the Commencement Date of Operation, at a time, when all pieces of equipment, which are normally anticipated to operate, are operating at a capacity that is expected to generate the highest noise levels under normal plant operation, all in accordance with the procedures specified by Publication NPC-103.

SOIL SAMPLING

45. (a) The Company shall carry out Soil Sampling for cadmium, lead, chromium, nickel and mercury in a geographic area that may be affected by emissions from the Facilities.

(b) The Company shall complete the first Soil Sampling not later than May 31, 2001 in accordance with the Soil Sampling Program described in the attached Schedule 16.

(c) The Company shall repeat the Soil Sampling every three years or less often as agreed upon in writing by the District Manager.

SECTION 5 REPORTING, RECORDING AND NOTIFICATION

REPORT ON OPERATION OF THE FACILITIES

46. The Company shall prepare an annual report on the operation of the Facilities, and submit the said report to the District Manager not later than May 1st of each year covering the previous twelve-month period ending March 31st. Each report shall include, but not be limited to the following:

Record of Conversation March 25/02

Present: John Pappain KMS
Dan Pearen KMS
Bob Adcock MOE

* I confirmed with Bob that the annual report should only ref the Monthly/Qtr Reports. He does not want second set of Monthly/Qtr Reports.

(1) Monthly Waste Processing Rate for each month during the reporting period calculated in accordance with the attached Schedule 17;

(2) Average Daily Waste Processing Rate for each month during the reporting period calculated in accordance with the attached Schedule 17;

(2) total Monthly Steam Production Rate and the Average Evaporation Rate for each of the five Incinerators for each month during the reporting period calculated in accordance with the attached Schedule 17;

(3) minimum and maximum 24-hour average hourly Steam Production Rate for each of the five Boilers for each month during the reporting period;

(4) any environmental and operational problems, including spills, Incinerator downtime, Air Pollution Control Train, Mercury Control System and NO_x and Dioxin Control System malfunctions as well as Continuous Emission Monitoring System and Continuous Process Control malfunctions that may have negatively impacted the quality of the environment, and any mitigative actions taken, including a summary of any environmental complaints received; and

(5) summary of maintenance and repair activities in relation to the Facilities, including calibration and testing activities, during the reporting period.

SOURCE TESTING REPORT

47. The Company shall prepare and submit a report on each Source Testing to the Director, the Manager and the Regional Director within ninety days of the completion of the Source Testing. The report shall be in the format specified in the Source Testing Code, and shall include, but not be limited to:

(1) an executive summary;

(2) dates when Source Testing was carried out;

(3) process description, records of waste composition and feed rate during the source measurement;

(4) records of operating conditions, including but not limited to:

(a) records of all Continuous Emission Monitoring Systems, including temperature and pressure sensors, for the period when the Source Testing was taking place;

(b) liquid and/or reagent and gas flow rates for all components of the Mercury Control System, the Air Pollution Control Trains and the NO_x and Dioxin Control System, including the conditioning towers, the dry-lime reactors, the sodium tetrasulphide injection system and the ammonia injection system;

(c) any other records that may affect the evaluation of the Source Testing report;

(5) procedures followed during the Source Testing and any deviation from the proposed test protocol and the reasons therefor;

(6) the results of the analyses of the stack emissions;

(7) a summary table that compares the Source Testing results, the monitoring data and the records of operating conditions during the Source Testing to the requirements imposed by the Act, the Regulation and/or the Performance Conditions;

(8) a proposal or a proposed revision for an Operating Window.

REPORT ON CONTINUOUS EMISSION MONITORING SYSTEMS:

VERIFICATION OF DESIGN AND PERFORMANCE SPECIFICATIONS

48. (1) The Company shall prepare a report on the tests carried out on the Continuous Emission Monitoring Systems;

(2) The report, pursuant to subsection (1), shall include the following:

(a) name of the Company/facility and the process being monitored;

(b) identification of the person(s) responsible for operational and conditioning test periods;

(c) description of the Continuous Emission Monitoring System;

(d) manufacturer, model and serial number for each sampling system and analyzer;

(e) schematic of:

(i) the measurement path location for all in-situ continuous emission monitors; and

(ii) sampling probe location for all extractive continuous emission monitors;

(f) monitor path length in metres, where applicable;

(g) zero gas quality grade and supplier, where applicable;

(h) calibration gas analysis and supplier, where applicable;

(i) upscale calibration value in percent opacity;

(j) results of the Design and Performance Specification tests; and

(k) any other relevant information.

(3) The Company shall submit the report, pursuant to subsections (1) and (2) to the Director, the Manager and the District Manager within thirty days of the Design and Performance Specification tests having been carried out.

REPORTING OF CONTINUOUS MONITORING RESULTS

49. (1) The Company shall prepare a quarter annual reports on the readings of the continuous monitoring systems, including temperature, flow measurement, moisture, opacity, carbon monoxide, oxygen, oxides of nitrogen and hydrogen chloride;

(2) each report, pursuant to subsection (1), shall include:

(a) the minimum and maximum 1-hour average and 4-hour average readings for carbon monoxide on a daily basis;

(b) minimum and maximum 1-hour average and 24-hour average readings for hydrogen chloride on a daily basis;

(c) minimum and maximum 1-hour average and 24-hour average readings for oxides of nitrogen on a daily basis;

(c) minimum and maximum 6-minute average and 2-hour average opacity on a daily basis;

(d) minimum and maximum 10-minute average and 4-hour average oxygen on a daily basis;

(c) minimum and maximum 30- minute average temperature measurements on a daily basis;

(e) number and duration of excursions from the relevant Performance Conditions for the following parameters:

(i) temperature at the outlet of the secondary chamber of any and all of the five Incinerators below 1000°C;

(ii) opacity, more than 5 percent or more than 10-percent pursuant to the relevant Performance Condition;

(iii) 4-hour average concentration of carbon monoxide more than 35 parts per million by dry volume;

(iv) 4-hour average concentration of oxygen below 6 percent by dry volume;

(v) 24-hour average concentration of hydrogen chloride more than 15 parts per million by dry volume normalized to 11 percent oxygen;

(vi) 24-hour average concentration of oxides of nitrogen more than 94 parts per million by dry volume normalized to 11 percent oxygen;

(f) reasons for excursions;

(g) corrective measures taken to eliminate excursions; and

(h) any other relevant information.

(3) The Company shall submit the quarter annual reports not later than thirty days after the end of each quarterly reporting period:

(a) to the Director, Manager and the District Manager during the first 12 months following the Commencement Date of Operation; and

(b) thereafter to the District Manager.

ACOUSTIC AUDIT REPORT

50. (1) The Company shall prepare and submit a report on the acoustic audit measurements, prepared by an Independent Acoustical Consultant, in accordance with Publication NPC-233 to the

District Manager and the Director not later than three (3) months after completion of the acoustic audit measurements;

(2) the report, pursuant to subsection (1) shall include:

(a) a description of all potential noise generating equipment and operations at the Facilities, including processing rates during the audit measurements; and

(b) an overall noise impact on receptors.

(3) The Director may not accept the results of the acoustic audit if the requirements of Publication NPC-233 were not followed.

(4) If the Director does not accept the results of the acoustic audit the Director may require the Company to repeat the acoustic audit.

SOIL SAMPLING REPORT

51. The Company shall submit a report on the Soil Sampling to the District Manager not later than one month after completing the Soil Sampling, with each report comparing the analytical results to the results obtained during the previous Soil Sampling.

NOTIFICATION OF AUTHORITIES

52. The Company shall notify the District Manager in writing, prior to the Commencement Date of Operation, as to whether or not the construction of the Facilities has been carried out in accordance with this Certificate to a point of substantial completion.

53. (1) The Company shall forthwith notify the Director, Regional Director, District Manager, Spills Action Centre and Office of the Commissioner of Works for the Regional Municipality of Peel by telephone, when any of the following occur as a result of conditions of this Certificate:

(a) Waste Processing Rate reduction;

(b) waste feed cut off;

(c) failure of one or both of the two Air Pollution Control Trains;

(d) power failure;

(e) use of Bypass Stack; and/or

(f) failure of any of the continuous monitoring systems.

(2) In addition, the Company shall prepare and submit a written report to the District Manager with respect to any of the said occurrences, within five calendar days of the occurrence, in the following format:

(a) date of the occurrence;

(b) general description of the occurrence;

(c) duration of the occurrence;

(d) effect of the occurrence on the emissions from the Facilities;

(e) measures taken to alleviate the effect of the occurrence on the emissions from the Facilities; and

(f) measures taken to prevent the occurrence of the same or similar occurrence in the future.

54. The Company shall ensure that necessary hardware and software are provided at a location available to the public, to provide on-line real-time reporting of the operating parameter data for the facility, including acceptable operating limits, stack emissions, and all other parameters for which continuous monitoring is required and that continuous records of the same be kept and made available to the public.

<u>RECORD RETENTION</u>

55. The Company shall retain at the Site for a period not less than two years from the date of their creation, all records relating to monitoring, performance, equipment maintenance, waste quality and quantity, including, but without limiting the generality of the foregoing:

(1) all original records produced by the recording devices associated with the Continuous Emission Monitoring Systems;

(2) all calibration and maintenance records for the Continuous Emission Monitoring Systems;

(3) all records produced during any Source Testing;

(4) all records relating to inspection and maintenance of any part of the Facilities;

(5) all records relating to the malfunctioning of any Continuous Emission Monitoring System, any part of either of the Air

Pollution Control Trains, Mercury Control System, NO_x and Dioxin Control System, any burner, any fan that supplies air to any of the Incinerators, and any fixture or appurtenance that may adversely affect the performance of any of the Incinerators, either of the Air Pollution Control Trains or any of the Continuous Emission Monitoring Systems;

(6) all records relating to any bypass of either of the Air Pollution Control Trains and/or use of the Bypass Stack; and

(7) all complaint response forms.

56. The Company shall make all records required by this Certificate, available to staff of the Ministry upon request.

SECTION 6 MISCELLANEOUS

ADDITIONAL TESTING REQUIREMENTS

57. The Director or the Regional Director may require in writing, making reference to this Certificate and this condition, that the Company repeat the Source Testing in the event that any stack test is not acceptable and/or any time in the event that there is evidence that the nature and/or the quantity of emissions may have changed.

The reasons for the imposition of these conditions are as follows:

1. Definitions are included to clarify the meaning of specified terms used in the Certificate.

2. The reason for Conditions 2 and 17 is to ensure that the Site is operated in accordance with the application and supporting information submitted by the Company, and not in a manner which the Director has not been asked to consider.

3. The reason for Conditions 3, 4, 5 and 7 is to clarify the legal rights and responsibilities of the Company.

4. The reason for Condition 6 is to ensure that the appropriate Ministry staff have ready access to the operations of the Site which are approved under this Certificate. The Condition is supplementary to the powers of entry afforded a Provincial Officer pursuant to the *Environmental Protection Act*, the *Ontario Water Resources Act* and the *Pesticides Act*, as amended.

5. The reason for Conditions 18-36 inclusive is to ensure that the Site is operated in a manner which does not result in a nuisance or a hazard to the health and safety of the environment or people.

6. The reason for Conditions 8-11 inclusive, and 16 is to outline the minimum performance requirements considered necessary to prevent an adverse effect resulting from the operation of the Equipment.

7. The reason for Conditions 12-15 inclusive, 37-46 inclusive, and 58 is to require the Company to gather accurate information so that the environmental impact and subsequent compliance with the Act, the Regulations and this Certificate can be verified.

8. The reason for Conditions 47-57 inclusive is to require the Company to retain records and provide information to the Ministry so that the environmental impact and subsequent compliance with the Act, the Regulation and this Certificate can be verified.

Schedule 3

This Schedule 3 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, dated February 14, 2001.

Table A: CALCULATION OF TOXICITY EQUIVALENT DIOXIN AND FURAN CONCENTRATION

Dioxin/Furan Isomers of Concern	International Toxicity Equivalency Factors (I-TEF's)	Concentration pg/m3 (Analytically measured)	Toxicity Equivalent (TEQ) pg TEQ/m3
A	B	C	D (D = B x C)
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1		
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	0.5		
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	0.1		
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	0.1		
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	0.1		
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	0.01		
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	0.001		
2,3,7,8-Tetrachlorodibenzofuran	0.1		
2,3,4,7,8-Pentachlorodibenzofuran	0.5		
1,2,3,7,8-Pentachlorodibenzofuran	0.05		
1,2,3,4,7,8-Hexachlorodibenzofuran	0.1		
1,2,3,6,7,8-Hexachlorodibenzofuran	0.1		
1,2,3,7,8,9-Hexachlorodibenzofuran	0.1		
2,3,4,6,7,8-Hexachlorodibenzofuran	0.1		
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.01		
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.01		
1,2,3,4,6,7,8,9-Octachlorodibenzofuran	0.001		

TOTAL TOXICITY EQUIVALENT

NOTE: "TOTAL TOXICITY EQUIVALENT" in the above Table A of Schedule 3 is the sum of toxicity equivalent concentrations of individual isomers.

The above Table A of Schedule 3 is intended to assist in the calculation required to obtain a toxicity equivalent concentration of emissions that contain various polychlorinated dioxin and furan isomers (compounds).

In order to calculate a concentration that reflects the overall toxicity of the dioxin and furan emissions from a source, International Toxicity Equivalency Factors (I-TEFs) are applied to 17 dioxins and furan isomers of concern set out in Column A of Table A. The most toxic of all dioxin and furan isomers is 2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin) and therefore its I-TEF is identified as 1.0 in Column B of Table A. The toxicity of the other dioxin and furan isomers is identified in Column B of Table A relative to 2,3,7,8-TCDD. For instance, 2,3,4,7,8-Pentachlorodibenzofuran is half as toxic as 2,3,7,8-TCDD and therefore its I-TEF is 0.5.

The actual toxicity equivalent concentration (TEQ; to be inserted in Column D) of each isomer in relation to 2,3,7,8-TCDD is calculated by multiplying the measured concentration of the isomer (to be inserted in Column C) by the I-TEF of that isomer (set out in Column B). The measured concentration to be inserted in Column C is the concentration that has been calculated based on sampling and analysis of a gas stream as part of a source testing campaign.

The total toxicity equivalent concentration of dioxins and furans discharged in the gas stream from a source is then obtained by summing up all of the individual TEQ values in Column D for each of the isomers of concern in Column A as shown at the bottom of Column D (TOTAL TOXICITY EQUIVALENT).

Compliance with the stack concentration limit for dioxin and furan emissions is achieved if the calculated TOTAL TOXICITY EQUIVALENT is less than the limit set out in the relevant Performance Condition ("the toxicity equivalent concentration of dioxins and furans in the Undiluted Gases in the Main Stack"). A similar approach shall be used to assess whether or not the measured emissions, as applied in a dispersion model, comply with the Point of Impingement concentration limit for dioxins and furans set out in Schedule 4 of this Certificate.

The above I-TEF scheme is intended to be used with isomer specific analytical results. In cases where results are reported by congener group only, staff at the Ministry's Standards Development Branch should be contacted for appropriate procedures to convert non-isomer specific data to TEQs.

Schedule 4

This Schedule 4 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, dated February 14, 2001.

Column 1	Column 2	Column 3
Contaminant	**Unit of Concentration**	**Concentration at Point of Impingement (half hour average)**
Aluminum oxide	micrograms of aluminum oxide per cubic metre of air	100
Arsenic	total micrograms of arsenic in free and combined form per cubic metre of air	1
Barium	total micrograms of water soluble barium per cubic metre of air	30
Phosphorus Pentachloride	micrograms of phosphorus pentachloride per cubic metre of air	30
Selenium	total micrograms of selenium in free and combined form per cubic metre of air	20
Respirable Silica (less than 10 micrometres)	total micrograms of silica per cubic metre of air	15
Dioxins and furans	picograms (TEQ) per cubic metre of air	15
1,2,4 - Trichlorobezene	micrograms of 1,2,4 - Trichlorobezene per cubic metre of air	100
Pentachlorophenol	micrograms of Pentachlorophenol per cubic metre of air	60
Polychlorinated Biphenyls	nanograms of Polychlorinated Biphenyls per cubic metre of air	450
Naphthalene	micrograms of Naphthalene per cubic metre of air	36
Benzo(a)pyrene	nanograms of Benzo(a)pyrene per cubic metre of air	3.3

SCHEDULE 5

This Schedule 5 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, dated February 14, 2001.

PARAMETER:
Carbon Monoxide

INSTALLATION:
The Continuous Carbon Monoxide Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of carbon monoxide in the Main Stack and the undiluted gases leaving each of the five Economizers, and shall meet the following installation specifications.

PARAMETERS	SPECIFICATION
1. Range (parts per million, ppm):	0 to ≥ 100 ppm
2. Calibration Gas Ports:	close to the sample point

PERFORMANCE:
The Continuous Carbon Monoxide Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	SPECIFICATION
1. Span Value (nearest ppm equivalent):	2 times the average normal concentration of the source
2. Relative Accuracy:	≤ 10 percent of the mean value of the reference method test data or ± 5 ppm whichever is greater
3. Calibration Error:	≤ 2.5 percent of actual concentration
4. System Bias:	≤ 4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check:	all system components checked
6. Zero Calibration Drift (24-hour):	≤ 5 percent of span value
7. Span Calibration Drift (24-hour):	≤ 5 percent of span value
8. Response Time (90 percent response to a step change):	≤ 180 seconds (Economizers), 240 seconds (Main Stack)
9. Operational Test Period:	≥ 168 hours without corrective maintenance

CALIBRATION:
Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

RELIABILITY:

The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter, excluding calibration time (Main Stack) or excluding calibration and maintenance time (Economizers).

SCHEDULE 6

This Schedule 6 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, dated February 14, 2001.

PARAMETER:
Oxygen

INSTALLATION:
The Continuous Oxygen Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of oxygen in the Main Stack and the undiluted gases leaving each of the five Economizers, and shall meet the following installation specifications.

PARAMETERS	SPECIFICATION
1. Range (percentage):	0 - 20 or 0 - 25
2. Calibration Gas Ports:	close to the sample point

PERFORMANCE:
The Continuous Oxygen Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	SPECIFICATION
1. Span Value (percentage):	2 times the average normal concentration of the source
2. Relative Accuracy:	≤ 10 percent of the mean value of the reference method test data
3. Calibration Error:	0.25 percent O_2
4. System Bias:	≤ 4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check:	all system components checked
6. Zero Calibration Drift (24-hour):	≤ 0.5 percent O_2
7. Span Calibration Drift (24-hour):	≤ 0.5 percent O_2
8. Response Time (90 percent response to a step change):	≤ 90 seconds
9. Operational Test Period:	≥ 168 hours without corrective maintenance

CALIBRATION:
Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time

for each calendar quarter during the first full year of operation, and 95 percent thereafter, excluding calibration time (Main Stack) or excluding calibration and maintenance time (Economizers).

Schedule 7

This Schedule 7 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, dated February 14, 2001.

PARAMETER:
Hydrogen Chloride

INSTALLATION:
The Continuous Hydrogen Chloride Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of hydrogen chloride in the Main Stack and in the gases leaving each of the two Air Pollution Control Trains (APC), and shall meet the following installation specifications.

PARAMETERS	SPECIFICATION
1. Range (parts per million, ppm):	0 to ≥ 100 ppm
2. Calibration Gas Ports:	close to the sample point

PERFORMANCE:
The Continuous Hydrogen Chloride Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	SPECIFICATION
1. Span Value (nearest ppm equivalent):	2 times the average normal concentration of the source
2. Relative Accuracy:	≤ 20 percent of the mean value of the reference method test data or ± 5 ppm whichever is greater
3. Calibration Error:	≤ 2 percent of actual concentration
4. System Bias:	≤ 4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check:	all system components checked
6. Zero Calibration Drift (24-hour):	≤ 5 percent of span value (APC), 2 percent (Main Stack)
7. Span Calibration Drift (24-hour):	≤ 5 percent of span value (APC), 2 percent (Main Stack)
8. Response Time (90 percent response to a step change):	≤ 240 seconds (Main Stack), 300 seconds (APC)
9. Operational Test Period:	≥ 168 hours without corrective maintenance

CALIBRATION:
The monitor shall be calibrated daily at the sample point, to ensure that it meets the drift limits specified above, during the periods of the operation of the Equipment. The results of all calibrations shall be recorded at the time of calibration.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 5 minutes or better.

RELIABILITY:

The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent thereafter, excluding calibration time (Main Stack) or excluding calibration and maintenance time (APC).

Schedule 8

This Schedule 8 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, dated February 14, 2001.

PARAMETER:
Nitrogen Oxides

INSTALLATION:
The Continuous Nitrogen Oxide Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of nitrogen oxides in the Main Stack and in the undiluted gases in the hot gas ducting ahead of the ECT prior to the duct leading into the Bypass Stack, and shall meet the following installation specifications.

PARAMETERS	SPECIFICATION
1. Analyzer Operating Range (parts per million, ppm):	0 to ≥ 200 ppm
2. Calibration Gas Ports:	close to the sample point

PERFORMANCE:
The Continuous Nitrogen Oxides Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	SPECIFICATION
1. Span Value (nearest ppm equivalent):	2 times the average normal concentration of the source
2. Relative Accuracy:	≤ 10 percent of the mean value of the reference method test data
3. Calibration Error:	≤ 2 percent of actual concentration
4. System Bias:	≤ 4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check:	all system components checked
6. Zero Calibration Drift (24-hour):	≤ 2.5 percent of span value
7. Span Calibration Drift (24-hour):	≤ 2.5 percent of span value
8. Response Time (90 percent response to a step change):	≤ 240 seconds (Main Stack), 200 seconds (ECT)
9. Operational Test Period:	≥ 168 hours without corrective maintenance

CALIBRATION:
Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent thereafter, excluding calibration time.

SCHEDULE 9

This Schedule 9 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, dated February 14, 2001.

PARAMETER:
Opacity

A. OPACITY MONITOR IN THE MAIN STACK

INSTALLATION:
The continuous Opacity Monitor shall be installed at an accessible location where the measurements are representative of the actual opacity of the gases in the Main Stack and shall meet the following design and installation specifications.

	PARAMETERS	SPECIFICATION
1.	Wavelength at Peak Spectral Response (nanometres, nm):	500 - 600
2.	Wavelength at Mean Spectral Response (nm):	500 - 600
3.	Detector Angle of View:	≤ 5 degrees
4.	Angle of Projection:	≤ 5 degrees
5.	Range (percent of opacity):	0 -100

PERFORMANCE:
The Continuous Opacity Monitor shall meet the following minimum performance specifications for the following parameters.

	PARAMETERS	SPECIFICATION
1.	Span Value (percent opacity):	2 times the average normal opacity of the source
2.	Calibration Error:	≤ 3 percent opacity
3.	Attenuator Calibration:	≤ 2 percent opacity
4.	Response Time (95percent response to a step change):	≤ 10 seconds
5.	Schedule for Zero and Calibration Checks:	daily minimum
6.	Procedure for Zero and Calibration Checks:	all system components checked
7.	Zero Calibration Drift (24-hours):	≤ 2 percent opacity
8.	Span Calibration Drift (24-hours):	≤ 2 percent opacity
9.	Conditioning Test Period:	≥ 168 hours without corrective maintenance
10.	Operational Test Period:	≥ 168 hours without corrective maintenance

CALIBRATION:
The monitor shall be calibrated, to ensure that it meets the drift limits specified above, during the periods of the operation of the Equipment. The results of all calibrations shall be recorded at the time of calibration.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 30 seconds or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter, excluding calibration time.

B. OPACITY MONITORS IN THE BYPASS STACK AND BAGHOUSE EXIT

SELECTION AND INSTALLATION OF OPACITY MONITORS

1. The Company shall select and install opacity monitor for the Bypass Stack, described in the preamble of this Certificate, as follows:

   (1) Design and Performance Specifications, as well as the selection of the monitor locations shall be in compliance with **Specification 1. set out in Appendix B of 40 CFR 60,** with the following clarifications and/or exceptions:

   (a) the selected Upscale Calibration Value Attenuator shall produce a known opacity value between 20 percent and 40 percent; and

   (b) the Response Time shall be not more than 5 seconds.

2. The Company shall select and install opacity monitors for the exit of each of the two baghouses, described in the preamble of this Certificate, in accordance with 1. above to the extent possible with the type of equipment approved by this Certificate, as amended.

TEST PROCEDURES FOR THE STACK OPACITY MONITOR

The Company shall verify compliance with the Design and Performance Specifications in accordance with the procedures described in **Specification 1. set out in Appendix B of 40 CFR 60.**

RELIABILITY:

The monitors shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter, excluding calibration and maintenance time.

SCHEDULE 10

This Schedule 10 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, dated February 14, 2001.

PARAMETER:
Temperature

LOCATION:
The sample points for the Continuous Temperature Monitors shall be located as indicated in item 9. of the preamble of this Certificate.

PERFORMANCE:
The Continuous Temperature Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	SPECIFICATION
1. Type:	"K", "J" or other type with equivalent measurement accuracy and suitable to the temperature range being measured
2. Accuracy:	± 1.5 percent of the minimum gas temperature

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor without a significant loss of accuracy and with a time resolution of 1 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 95 percent of the time for each calendar quarter.

SCHEDULE 11

This Schedule 11 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, dated February 14, 2001.

SELECTION AND INSTALLATION OF MOISTURE CEMS

The Company shall select and install a continuous monitoring system (CEMS), to measure moisture content of the stack gases, including the probes, sampling lines and the analyzer, as follows:

(1) Design and Performance Specifications shall be in accordance with 40 CFR 60, Appendix B, Specification 4.

(2) The Company shall select the probe locations in compliance with 40 CFR 60, Appendix B, Specification 2.

TEST PROCEDURES FOR MOISTURE CEMS

The Company shall verify compliance with the Design and Performance Specifications in accordance with 40 CFR 60, Appendix B, Specification 4., with the reference method for the relative accuracy test being Method 4. of the Source Testing Code.

In furtherance of, but without limiting the generality of the foregoing, the mean difference between the calibration gas value and the analyzer response value at each of the four test concentrations shall be less than 5 percent of the measurement range.

SCHEDULE 12

This Schedule 12 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, dated February 14, 2001.

SOURCE TESTING FOR GASES AND PARTICULATE

1. GASES:

hydrogen chloride
carbon monoxide
carbon dioxide
oxides of nitrogen
oxygen
sulphur dioxide
total hydrocarbons

2. PARTICULATE

total suspended particulate matter and fractions in the suspended particulate matter for the following materials:

Aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, fluorides, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, phosphorous, selenium, silicon, silver, sodium, strontium, tin, titanium, vanadium, zinc

SCHEDULE 13

This Schedule 13 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, dated February 14, 2001.

SOURCE TESTING FOR OTHER CHLORINATED ORGANICS

Total dichlorobenzenes
total trichlorobenzenes
total tetrachlorobenzenes
pentachlorobenzene
hexachlorobenzene

Total dichlorophenols
total trichlorophenols
total tetrachlorophenols
total pentachlorophenols

Total polychlorinated biphenyls

SCHEDULE 14

This Schedule 14 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, dated February 14, 2001.

SOURCE TESTING FOR POLYCYCLIC ORGANIC MATTER

Acenaphthylene
acenaphthene
anthracene
benzo(a)anthracene
benzo(b)fluoranthene
benzo(k)fluoranthene
benzo(a)fluorene
benzo(b)fluorene
benzo(ghi)perylene
benzo(a)pyrene
benzo(e)pyrene
2-chloronaphthalene
chrysene
coronene
dibenzo(a,c)anthracene
9,10 - dimethylanthracene
7,12 - dimethylbenzo(a)anthracene
fluoranthene
fluorene
indeno(1,2,3 - cd)pyrene
2 - methylanthracene
3 - methylcholanthrene
1 - methylnaphthalene
2 - methylnaphthalene
1 - methylphenanthrene
9 - methylphenanthrene
naphthalene
perylene
phenanthrene
picene
pyrene
tetralin
triphenylene
dibenzo(a,h)anthracene
dibenzo(a,e)pyrene
quinoline
biphenyl
o-terphenyl
m-terphenyl
p-terphenyl

SCHEDULE 15

This Schedule 15 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, dated February 14, 2001.

SOURCE TESTING FOR VOLATILE ORGANIC MATTER

Acetaldehyde
acetone
acrolein
benzene
bromodichloromethane
bromoform
bromomethane
butadiene, 1,3 -
Butanone, 2 -
Carbon tetrachloride
chloroform
cumene
dibromochloromethane
dichlorodifluoromethane
dichloroethane, 1,2 -
Dichloroethene, trans - 1,2 -
Dichloroethene, 1,1 -
Dichloropropane, 1,2 -
Ethylbenzene
ethylene dibromide
formaldehyde
mesitylene
methylene chloride
styrene
tetrachloroethene
toluene
trichloroethane, 1,1,1 -
Trichloroethene
trichloroethylene, 1,1,2 -
Trichlorofluoromethane
trichlorotrifluoroethane
vinyl chloride
xylenes, m-, p- and o-

SCHEDULE 16

This Schedule 16 forms part of Certificate of Approval (Air) No. 3383-4RKM3Q, dated February 14, 2001.

SOIL SAMPLING PROGRAM

Purpose: To determine the level of selected trace metal species in the soil in the vicinity of the KMS Peel facility and compare those results to 1986 and subsequent levels.

Method: Select 10 sampling sites that are in areas that could be influenced by the KMS Peel facility, but that are not likely to have been disturbed since the mid 1980's.

Collect a core of approximately 1.5 centimetres in diameter from the top layer of the soil, not below approximately 5 centimetres from the surface, from each location, documenting the approximate location with GPS readings and photographs.

Soil samples to be places in plastic sampling bags and sent to laboratory for analysis for: cadmium, lead, chromium, nickel and mercury. Results to be reported in ppm concentrations.

Compare data from 2001 with that collected in 1986, and all subsequent data to data obtained during previous sampling, to determine if the average has changed .

Sampling site selection criteria should include locations within 1 - 2 kilometres of the KMS Peel facility, as well as three sites located outside that boundary for background comparisons. The following approximate locations are to be considered:

Northwest of the KMS Site

1. Alfred Kuehne Blvd where the creek passing through the KMS site crosses the road
2. In Victoria Park north of Victoria Crescent
3. In the park at Bramalea and Hwy 7

East of the KMS Site

4. Where the creek crosses Drew Road northeast of Bramalea Road.
5. In the park at Goreway and Derry Road to the west and south of the arena

North of the KMS Site

6. Our Lady of the Airways School off Airport Road
7. Off Rena Road where the west branch of Mimico Creek crosses the road
8. In the Clairville Conservation area off Hwy 7.

South of the KMS Site

9. In the park adjacent to Cardiff Blvd. west of Dixie Road and North of Derry.
10. In the cemetery at Tomken and Derry Road (southeast corner)

The limited sampling opportunities and the rapid changes in the area likely preclude any chance of establishing a cause effect relationship between the facility and ambient conditions, but the study will confirm if there have been any changes, and provide a baseline for future assessments.

SCHEDULE 17

This Schedule 17 forms part of Certificate of Approval(Air) No. 3383-4RKM3Q, dated February 14, 2001.

1. Calculation of Monthly Waste Processing Rate at the Site:

Monthly Waste Processed = $Waste_S$ + *Receipts* - *Unacceptable* - *Ferrous* - $Waste_F$

where $Waste_S$= *waste present on the tipping floor at start of month*

$Waste_F$= *waste present on the tipping floor at end of month*
Receipts = amount of waste Received across the weigh scales
Unacceptable = amount of waste shipped out across the scales
Ferrous = amount of recyclable ferrous recovered from Bottom Ash

2. Calculation of Average Daily Waste Processing Rate for the Site:

Average Daily Waste Processing Rate = *Monthly Waste Processed* at the Site/ *Operating Incinerator Days*

where

Operating Incinerator Days [OID] = *the sum of the number of days each Incinerator operated during the month determined to 2 decimal places based upon the time waste charging started after a shutdown for that unit and the time it finished before a shutdown.* This eliminates any heating up and cooling down time in the calculations.

3. Calculation of Average Monthly Waste Processing Rate for Unit "X":

Average Monthly Waste Processing Rate Unit "X" = *Average Daily Waste Processing Rate x*

Operating Incinerator Days for Unit "X"

where *"X" represents the identification number of the relevant Incinerator*

4. <u>Calculation of Average Evaporation Rate for Unit "X":</u>

Average Evaporation Rate Unit "X" = Total Monthly Steam Production Rate for Unit "X" / Average Monthly Waste Processing Rate for Unit "X"

Ministry of the Environment
2 St. Clair Ave. West
Toronto ON M4V 1L5

Ministère de l'Environnement
2, avenue St. Clair Ouest
Toronto ON M4V 1L5

Ontario

RECEIVED FEB - 6 2002

ENVIRONMENTAL ASSESSMENT
AND APPROVALS BRANCH
Tel. (416) 314-7967
Fax (416) 314-8452

Date: January 30, 2002

John Pappain, Vice President, Canadian Operations
KMS Peel Inc.
7656 Bramalea Road
Brampton, Ontario
L6T 5M5

Dear Mr. Pappain:

RE: Certificate No. 4591-56VSTN
Waste Disposal Site

Please find attached your Provisional Certificate of Approval No. 4591-56VSTN for a Waste Disposal Site.

This Certificate is being issued to you subject to a number of conditions. Please ensure that you understand and comply with each of these conditions.

Please note that this approval does not relieve you from compliance with any other Federal, Provincial or Municipal Acts, Regulations or By-laws.

This Certificate of Approval revokes and replaces Provisional Certificate of Approval (Waste Disposal Site) No. 8834-47TQLFV, dated February 14, 2001. This amended Certificate of Approval is being issued to incorporate various administrative corrections in the text of the Certificate.

Should you have any questions regarding this Certificate, please contact A.M. Pennanen, P.Eng., Hazardous Waste Project Engineer at (416) 314-7998.

Yours truly,

I. Parrott, P. Eng.,
Director,
Section 39,
Environmental Protection Act.

Encls.

cc: J.Budz, District Manager, Halton-Peel District Office
Richard Brown, Business & Fiscal Planning Branch
Director, Environmental Monitoring and Reporting Branch
Clerk, The City of Brampton
Clerk, The Regional Municipality of Peel

Under the Environmental Protection Act and the regulations and subject to the limitations thereof, this Certificate of Approval is issued to:

KMS Peel Inc.
7656 Bramalea Road
Brampton, Ontario
L6T 5M5

for the establishment, use and operation of a Waste Disposal Site (Incineration), complete with an Energy from Waste facility, with the main components as described in the corresponding Certificate of Approval (Air) issued to the Energy from Waste Facility, as may be amended from time to time, together with an Ash Handling System, as also referenced in the Order in Council dated October 4, 2000 together with Notice of Approval to Proceed with the Undertaking, EA File No. PR-KM-02, under the Environmental Assessment Act.

all in accordance with the following plans and specifications:

The applications and supporting information as listed in Schedule "A" which is attached to this Certificate of Approval and forms part of this Certificate,

Located: Lot 14, Concession 4, City of Brampton, The Regional Municipality of Peel

which includes the use of the Site only for the Disposal of the following categories of waste (Note: Use of the site for additional categories of wastes requires a new application and amendments to the Certificate of Approval):

solid non-hazardous waste from domestic, commercial and industrial sources, all collected within the Regional Municipalities of Halton, Peel, Durham and York as well as The Corporation of The City of Toronto, including solid non-hazardous waste collected at the Pearson International Airport originating from food service establishments as well as aircraft and airside areas, including Canada Customs.

This Certificate of Approval revokes and replaces Provisional Certificate of Approval (Waste Disposal Site) No. 8834-47TQLFV, dated February 14, 2001.

Definitions

For the purposes of this Certificate of Approval:

1. "Act" means the *Environmental Protection Act*, R.S.O. 1990, C. E-19 as amended;

2. "Air Certificate" means the corresponding Certificate of Approval (Air), as may be amended from time to time, issued under section 9 of the *Act* to cover the same Facilities;

3. "Air Pollution Control Train" means one of the two systems that include a gas conditioning tower, referred to as the Evaporative Cooling Tower (ECT), venturi reactor tower with lime injection and a baghouse, all as described in item 5 of the preamble of the Air Certificate;

4. "APC Residue" means the residue collected from the two Air Pollution Control Trains;

5. "Bottom Ash" means the ash residue resulting from combustion of waste, discharged from the primary chambers of the Incinerators into the ash hall and includes the Bottom Ash that has been processed through the Bottom Ash Processing System;

6. "Bottom Ash Processing System" means the bar screen grizzly, vibrating pan feeder, oscillating inclined screen, magnetic separator and an ash dryer, all as described in section 4.3 of Attachment 3 of the Application for Amendment of the Provisional Certificate of Approval (Waste Disposal Site) Number A220216;

7. "Bypass Stack" means the alternate stack that may be used either during the time when the NO_x and Dioxin Control System is off-line or in emergency situations when it is necessary to discharge emissions that have not been controlled by the Mercury Control System, the Air Pollution Control Trains and the NO_x and Dioxin Control System;

8. "Certificate" means this Certificate of Approval including its schedules, if any, issued under section 27 of the *Act*;

9. "Commencement Date of Operation" means the date when waste is first fed into all five Incinerators;

10. "Company" means KMS Peel Inc. and includes its successors and assignees;

11. "Director" means a Director of the Environmental Assessment and Approvals Branch of the Ministry, or successor;

12. "District Manager" means the District Manager of the Halton-Peel District of the Ministry, or successor;

13. "Facilities" means the entire energy-from-waste facility, including, but not limited to the major components as listed in the preamble of the Air Certificate, and all fixtures, appurtenances and equipment;

14. "Flyash" means the particulate matter collected from the Boiler and the Economizer, referenced in the Air Certificate;

15. "Incinerator" means one of the five two-stage thermal destruction units referenced in the preamble of the Air Certificate;

16. "Internal Power Supply" means the steam turbine generator set and the natural gas fired combustion turbine, as referenced in the Air Approval;

17. "NO_x and Dioxin Control System" means the equipment associated with and the selective catalytic reduction (SCR) reactor described in item 7 of the preamble of the Air Certificate;

18. "Ministry" means the Ontario Ministry of the Environment, or successor, unless specific reference is made to another Ministry;

19. "O. Reg. 347" means Ontario Regulation 347, R.R.O. 1990, as amended;

20. "O. Reg. 558" means Ontario Regulation 558/00 which amends O. Reg. 347;

21. "Process" means the Receipt, handling of the waste and placement of waste into the tipping floor of the Facilities, Destruction of the waste in one of the five incinerators, and segregation, handling and disposal of all Residual Wastes;

    and "Processed" and "Processing" have a corresponding meaning;

22. "Protocol" means Protocol for Sampling and Evaluating Fly Ash from Non-Hazardous Solid Waste Incineration Facilities, Ministry of the Environment and Energy, October 1990;

23. "Provincial Officer" means a person who is designated by the Ministry of the Environment as a Provincial Officer for the purposes of the *Environmental Protection Act*, the *Ontario Water Resources Act*, the *Pesticides Act*, and their respective regulations;

24. "Receipt" means the arrival of waste at the Site, whether remaining in the vehicles used to transport the waste to the Site or unloaded from the vehicles used to transport the waste to the Site, and for the purposes of this definition, vehicles used to transport waste to the Site shall include any vehicle parked, waiting or queued on the road ways adjacent to or near the Site, and "Receive" and "Received" have a corresponding meaning;

25. "Residual Waste" means the Flyash, the APC Residue and the Bottom Ash, all generated as a result of Processing waste in the incinerators;

26. "SCR System" means the selective catalytic reactor and associated equipment, as described in item 7 of the preamble of the Air Certificate;

27. "Site" means the property located at Lot 14, Concession 4, City of Brampton, The Regional Municipality of Peel;

28. "Total Power Failure" means the loss of the external power supply and concomitant loss of all in-plant power generation;

29. "Trained" means a competent and knowledgeable in the following through instruction and practice:

    i. relevant waste management legislation, regulations and guidelines;

    ii. major environmental concerns pertaining to the waste to be handled;

iii. occupational health and safety concerns pertaining to the processes and wastes to be handled;

iv. emergency management procedures for the process and wastes to be handled;

v. use and operation of the equipment to be used;

vi. emergency response procedures;

vii. company specific written procedures for the control of nuisance conditions;

viii.the requirements of this Certificate.

and subject to the following conditions:

A. GENERAL REQUIREMENTS

1. Except as otherwise provided by these conditions, the Site shall be designed, developed, used, maintained and operated, and all facilities, equipment and fixtures shall be built and installed, in accordance with the Application for a Certificate Approval (Waste Disposal Site) dated September 11, 2000, and the supporting documentation, plans and specifications listed in Schedule "A".

2. The requirements specified in this Certificate are the requirements under the *Environmental Protection Act*, R.S.O. 1990 (the Act). The issuance of this Certificate in no way abrogates the Company's legal obligations to take all reasonable steps to avoid violating other applicable provisions of this legislation and other legislation and regulations.

3. The requirements of this Certificate are severable. If any requirement of this Certificate, or the application of any requirement of this Certificate to any circumstance, is held invalid, the application of such requirement to other circumstances and the remainder of this Certificate shall not be affected in any way.

4. The Company shall ensure compliance with all the terms and conditions of this Certificate and the Air Certificate. Any non-compliance constitutes a violation of the *Environmental Protection Act*, R.S.O. 1990 and is grounds for enforcement.

5. (a) The Company shall, forthwith upon request of the Director, District Manager, or Provincial Officer (as defined in the Act), furnish any information requested by such persons with respect to compliance with this Certificate, including but not limited to, any records required to be kept under this Certificate; and

   (b) In the event, the Company provides the Ministry with information, records, documentation or notification in accordance with this Certificate (for the purposes of this condition referred to as "Information"),

      i. the receipt of Information by the Ministry;

ii. the acceptance by the Ministry of the Information's completeness or accuracy; or

iii. the failure of the Ministry to prosecute the Company, or to require the Company to take any action, under this Certificate or any statute or regulation in relation to the Information;

shall not be construed as an approval, excuse or justification by the Ministry of any act or omission of the Company relating to the Information, amounting to non-compliance with this Certificate or any statute or regulation.

6. The Company shall allow Ministry personnel, or a Ministry authorized representative(s), upon presentation of credentials, to:

   (a) carry out any and all inspections authorized by Section 156, 157 or 158 of the *Environmental Protection* Act, R.S.O. 1990, Section 15, 16 or 17 of the *Ontario Water Resources Act*, R.S.O. 1990, or Section 19 or 20 of the *Pesticides Act*, R.S.O. 1990, as amended from time to time, of any place to which this Certificate relates; and,

   without restricting the generality of the foregoing, to:

   (b) i. enter upon the premises where the records required by the conditions of this Certificate are kept;

   ii. have access to and copy, at reasonable times, any records required by the conditions of this Certificate;

   iii. inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations required by the conditions of this Certificate; and

   iv. sample and monitor at reasonable times for the purposes of assuring compliance with the conditions of this Certificate.

7. (a) Where there is a conflict between a provision of any document referred to in Schedule "A", and the conditions of this Certificate, the conditions in this Certificate shall take precedence; and

   b. Where there is a conflict between documents listed in Schedule "A", the document bearing the most recent date shall prevail.

8. The Company shall ensure that all communications/correspondence made pursuant to this Certificate includes reference to this Certificate.

9. The Company shall notify the Director in writing of any of the following changes within thirty (30) days of the change occurring:

   (a) change of Company or operator of the Site or both;

(b) change of address or address of the new Company;

(c) change of partners where the Company or operator is or at any time becomes a partnership, and a copy of the most recent declaration filed under the *Business Names Act*, 1991 shall be included in the notification to the Director;

(d) any change of name of the corporation where the Company or operator is or at any time becomes a corporation, and a copy of the most current "Initial Notice or Notice of Change" (form 1 or 2 of O. Reg. 182, Chapter C-39, R.R.O. 1990 as amended from time to time), filed under the *Corporations Information Act* shall be included in the notification to the Director; and

(e) change in directors or officers of the corporation where the Company or operator is or at any time becomes a corporation, and a copy of the most current "Initial Notice or Notice of Change" as referred to in 9(d), supra.

10. In the event of any change in ownership of the Site, the Company shall notify in writing the succeeding owner of the existence of this Certificate, and a copy of such notice shall be forwarded to the Director.

11. Any information relating to this Certificate and contained in Ministry files may be made available to the public in accordance with the provisions of the *Freedom of Information and Protection of Privacy Act*, R.S.O. 1990, C. F-31.

12. The requirements of this Certificate of Approval are in addition to the requirements set out in the Air Certificate.

B RECEIPT, STORAGE AND HANDLING OF WASTE

General:

13. The Company shall not Receive waste that has been generated or has been previously transferred to any facility in Ontario from outside The Regional Municipalities of Halton, Peel, Durham and York as well as The Corporation of The City of Toronto, except for airside waste from domestic and international carriers as well as waste from the Canada Customs area collected at the Pearson International Airport.

14. All wastes shall be transported to and from the Site in accordance with O. Reg. 347.

15. All wastes, either liquid or solid, generated at this Site shall be appropriately segregated from the waste Received to be incinerated in the five Incinerators, and shall be disposed of at sites that are approved to receive those types of wastes, and in accordance with O. Reg. 347.

16. The maximum rate at which the Company may Receive waste at the Site shall be 1,400 tonnes per day up to a maximum of 182,000 tonnes per year.

17. The maximum amount of waste, including Residual Waste, that may be present at the Site at any time is limited to the following:

(a) 2,600 tonnes of waste to be incinerated in the five Incinerators;
(b) 600 tonnes of unprocessed Bottom Ash;
(c) 200 tonnes of Bottom Ash Processed in the Bottom Ash Processing System;
(d) 20 tonnes of Flyash;
(e) 30 tonnes of APC Residue;
(f) 6 tonnes of recyclable materials.

18. Incoming waste shall be visually inspected by a Trained Company representative, prior to being accepted at the Site, to ensure that the Site is approved to accept that type of waste.

19. (a) All waste handling activities shall occur indoors at all times;

(b) All wastes Received at, but not Processed at the Site, shall be stored indoors at all times, pending transfer to another facility approved to receive such wastes;

(c) wastes Received to be fed into the five Incinerators shall not be stored outside the building in any containers or in any vehicles.

20. The Company shall ensure that only waste haulers approved by the Ministry to handle these wastes are used to transport waste to and from the Site.

21. The Site shall be maintained in a secure manner to prevent unauthorized persons from entering the Site.

22. The Company shall ensure that the Site is operated in a manner that is clean, orderly and hygienic and that prevents any off-site impacts, including the impacts of vermin, vectors, dust, litter, noise and traffic on the environment and the public.

23. The Company shall ensure that all wastewater is discharged in accordance with the municipal sewer use by-law of The Regional Municipality of Peel.

Handling and Disposal of Residual Waste:

24. The Company shall transfer the Flyash and the APC Residue for disposal at a site approved to accept hazardous waste for disposal.

25. Bottom Ash that is not leachate toxic or severely toxic,s defined in section 1 of O. Reg. 347, as amended by section 1.(6) of O. Reg. a558 and as amended from time to time thereafter, is not considered hazardous waste and may therefore be disposed of at an approved sanitary landfill site.

26. The conveying of Flyash and the APC Residue shall be carried out using totally enclosed systems.

27. Bottom Ash shall not be mixed with the Flyash and/ or the APC Residue unless all Residual Waste is disposed of at a Waste Disposal Site that is approved to accept hazardous waste.

28. The transportation of Residual Waste off the site shall be carried out in watertight vehicles that will not allow fugitive dust emissions to occur from the Residual Waste into the natural environment.

Contingency Plan:

29. The Company shall promptly take all necessary steps to contain and clean up any spills which result from the operation of the Site. All spills and upsets, including the use of the Bypass Stack during Total Power Failure and/ or breakdown of both Air Pollution Control Trains, shall be immediately reported to the Ministry's Spills Action Centre at (416) 325-3000 or 1-800-268-6060 and shall be recorded as to the nature of the spill or upset, and the action taken for clean-up, correction and prevention of future occurrences.

30. The Company shall notify the local Fire Department regarding the Site operations and layout prior to the Commencement Date of Operation.

31. The Company shall maintain an emergency response and spill contingency plan at the Site at all times when the Site is operational and shall submit the same to the District Manager for his information, the local Fire Department and the City of Brampton for their reference prior to the Commencement Date of Operation. The emergency response and contingency plan shall contain, as a minimum:

    (a) emergency response procedures, including notification procedures in case of spills, fires and explosions;

    (b) list of home and business phone numbers and work locations of all person(s) responsible for the Site;

    (c) list of emergency phone numbers for the local Ministry office, Ministry's Spills Action Centre, and the Local Fire Department;

    (d) measures to prevent spills, fires and explosions;

(e) description and procedures for use of fire fighting as well as spill clean-up related equipment and control and safety devices;

(f) maintenance and testing program for spill clean-up equipment and fire fighting equipment;

(g) training of Site operators and Site emergency response personnel;

(h) an emergency Site plan, identifying the location and nature of wastes on Site.

32. The Company shall, as a minimum, review the emergency response and spill contingency plan on an annual basis, and, if amended, immediately submit the amended emergency response and contingency plan to the District Manager for his information, the local Fire Department and the City of Brampton.

C. OPERATION AND MAINTENANCE OF THE EQUIPMENT AND SITE

General:

33. The Company shall conduct regular inspections of the Facilities and Site to ensure that all pieces of equipment and Site are operated in a manner that will not negatively impact the environment. Any deficiencies detected during these regular inspections, that might negatively impact the environment, shall be promptly corrected. A written record shall be prepared, which includes the following:

(a) name and signature of Trained Company representative conducting the inspection;

(b) date and time of the inspection;

(c) list of pieces of equipment and areas of the Facilities inspected and all deficiencies that discovered that may negatively impact the environment;

(d) recommendations for remedial action and actions undertaken;

(e) date and time of maintenance activity; and

(f) a detailed description of the maintenance activity.

D. DESIGN AND PERFORMANCE REQUIREMENTS

Bottom Ash Quality:

34. The Company shall ensure that the organic content, measured as carbon, of the Bottom Ash does not exceed 10 percent by weight.

E. MONITORING

Testing of Bottom Ash:

35. The Company shall sample the Bottom Ash from at least one of the Incinerators in accordance with the procedures set out in the Protocol, except for sampling frequency and analytical requirements which are set out in **conditions 36. and 38.** below.

36. The Company shall analyze the Bottom Ash samples in accordance with Toxicity Characteristic Leaching Procedure referenced in section 1.(6) of O. Reg. 558, except for sampling and analyzing for severe toxicity which shall be carried out using unprocessed Bottom Ash.

37. The Company shall also analyze the Bottom Ash samples on an annual basis to determine their organic content, measured as carbon.

38. The Company shall sample and analyze the Bottom Ash within the first six months after the Commencement Date of Operation and thereafter once a year, except if the sampling and analysis indicate that the Bottom Ash is severely toxic or Leachate Toxic Waste as defined in section 1 of O. Reg. 347, as amended by section 1.(6) of O. Reg. 558 and as amended from time to time thereafter, in which case quarterly sampling and analysis shall be carried out as set out in the Protocol.

39. The Company shall prepare a report on the results of the Bottom Ash sampling and analysis and submit the said report to the District Manager not later than one (1) month after the sampling and analysis have been completed.

F. RECORD KEEPING AND REPORTING

General:

40. All records, monitoring data and reports required by the conditions of this Certificate shall be maintained at the Site for a minimum period of at least two (2) years from the date of their creation in a hard copy format and as an electronic record and shall be made available for inspection by staff of the Ministry. In furtherance of the above, the records shall also include, as a minimum, the following:

    (a) the sources, types and weights of all wastes Received on a daily basis;

    (b) the types, weights and destinations of all wastes and recyclable materials transferred from the Site on a daily basis;

Annual Report for the Site:

41. By March 31, 2001, and thereafter by each subsequent March 31st day, the Company shall prepare and submit to the District Manager an Annual Report covering all waste handling activities relating to the Site during the previous calendar year. Each such report shall include, but not be limited to, the following

information:

(a) the maximum amount of waste Received on any day during the reporting period;

(b) the total amount of waste Received during the reporting period;

(c) monthly summaries and the total amount of Bottom Ash transferred from the Site during the reporting period, including destination;

(d) monthly summaries and the total amount of Flyash transferred from the Site during the reporting period, including destination;

(e) monthly summaries and the total amount of APC Residue transferred from the Site during the reporting period, including destination;

(f) monthly summaries and the total amount of recyclable materials transferred from the Site during the reporting period, including destination;

(g) a statement as to compliance with all Conditions of this Certificate and with the inspection and reporting requirements of the Conditions contained herein;

(h) any recommendations to minimize environmental impacts and improve Site operations and monitoring programs; and

(i) dates, duration and reason for any use of the bypass stack as well as actions taken to eliminate the need for using the Bypass Stack.

G. INDEPENDENT TECHNICAL REVIEW

42. The Company shall ensure that an independent technical review of plant operations and technology be carried out by qualified and competent independent consultants at the end of each 5 year period following the Commencement Date of Operation, so long as the Facilities continue to operate. The said technical reviews shall consider and comment upon changing, upgrading, or retrofitting technology, plant and equipment and modifications of plant procedures and appropriate alternative courses of action with respect thereto required in order to continue to achieve the best available technology and improved air quality, at the time of the review and shall contain a cost/benefit analysis for each of the alternatives considered, from the point of view of both the inhabitants of the Regional Municipality of Peel and the Company.

The technical reviews shall also contain recommendations on the appropriate course of action, if any, to be taken in view of the findings contained therein. The Company shall co-operate and supply all necessary information required to carry out the technical reviews, which shall be published.

G. PUBLIC LIAISON COMMITTEE

43. The Company shall provide the opportunity for the establishment of a Liaison Committee with representation from the Company, the Regional Municipality of Peel, the Ministry, and the community so that the public can have direct and continuing involvement with the operation of the Facilities.

G. TRAINING

44. The Company shall ensure that staff Receiving and/ or Processing waste, handling waste, disinfecting or servicing equipment at the Site wear adequate protective clothing at all times in compliance with applicable provincial legislation and are trained with respect to:

(a) the terms, Conditions and operating requirements of this Certificate;

(j) the procedures for all transfer, Processing and storage operations;

(k) the operation and maintenance of the specific equipment which they operate at the Site;

(l) all emergency response procedures;

(m) any environmental concerns pertaining to the Site and wastes to be transferred/processed, including contingency measures and procedures for emergency response; and

(n) relevant waste management legislation and Regulations under the Act and Ontario Water Resources Act.

45. The Company shall develop, and periodicly update, a Training Plan, that includes, but is not limited to:

(a) the credentials of the trainer(s);

(b) the duration of the training course;

(c) the specific content of the training course, including any updated and supplementary information;

(d) the schedule for updating staff; and

(e) criteria to determine whether an individual trainee has met all the training objectives.

46. Staff shall be deemed to be Trained, if they successfully pass the appropriate components of the training courses.

47. The Company shall maintain an updated training manual at the Site at all times. The manual shall include, as a minimum:

(a) relevant waste management legislation, regulations and guidelines;

(b) environmental concerns pertaining to the wastes to be handled;

(c) emergency response and contingency plan for the Site and the wastes to be handled;

(d) operating procedures for any equipment to be used;

(e) procedures for prevention of conditions that may cause an adverse effect; and

(f) requirements of this Certificate.

H. FINANCIAL ASSURANCE

48. (a) Within fifteen (15) days of issuance of this Certificate, the Company shall ensure that the Director has received, Financial Assurance as defined in Section 131 of the Act, in the amount of one million **Canadian dollars ($1,000,000.00)**. This Financial Assurance shall be in a form and amount acceptable to the Director and shall provide sufficient funds for the analysis, transportation, Site clean-up, monitoring and disposal of all quantities of waste on the Site at any one time;

(b) No waste shall be accepted, Processed or transferred at the Site, unless the Ministry has received the appropriate amount of Financial Assurance;

(c) Commencing on March 31, 2002 and on an annual basis thereafter, the Company shall provide to the Director a re-evaluation of the amount of the Financial Assurance to facilitate the actions required under subcondition (a) above. The Financial Assurance shall be submitted to the Director within ten (10) days of written acceptance of the re-evaluation by the Director; and

(d) The amount of Financial Assurance is subject to review at any time by the Director and may be amended at his/her discretion. If any Financial Assurance is scheduled to expire or notice is received, indicating Financial Assurance will not be renewed, and satisfactory methods have not been made to replace the Financial Assurance at least sixty (60) days before the Financial Assurance terminates, the Company shall forthwith replace the Financial Assurance with cash.

I. LIABILITY INSURANCE

49. The Company shall, at all times while the Site is operating, maintain an environmental impairment liability insurance policy in the amount of at least 15,000,000 Canadian dollars and a general third party liability insurance policy in the amount of at least 5,000,000 Canadian dollars.

J. COMPLAINT RESPONSE

50. If at any time, the Company receives complaints regarding the operation of the Site, the Company shall respond to these complaints according to the following procedure:

(a) The Company shall record each complaint on a formal complaint form entered in a sequentially numbered log book. The information recorded shall include the nature of the complaint, the name, address and the telephone number of the complainant and the time and date of the complaint;

(b) The Company, upon notification of the complaint shall initiate appropriate steps to determine all possible causes of the complaint, proceed to take the necessary actions to eliminate the cause of the complaint and forward a formal reply to the complainant and within 24 hours of the complaint having been received notify by telephone and in writing the District Manager of the complaint and the actions taken; and

(c) The Company shall prepare a report within one (1) week of the complaint date, listing the actions taken to resolve the complaint and any recommendations for remedial measures, and managerial or operational changes to reasonably avoid the reoccurrence of similar incidents.

K. CLOSURE PLAN

51. (a) Three (3) months prior to the planned closure of this Site, the Company shall provide to the Director, for approval, a written Closure Plan for the Site. This plan shall include, as a minimum, a description of the work that will be done to facilitate closure of the Site and a schedule for completion of that work; and

(b) Within four (4) months of closure of the Site, the Company shall provide the Director with a report, written by an independent, qualified consultant which confirms that the Site has been closed in accordance with the Closure Plan submitted and approved in accordance with subcondition(a)above.

SCHEDULE "A"

This Schedule "A" forms part of Certificate (Waste Disposal Site):

1. Application for a Certificate of Approval for a Waste Disposal Site (Processing), dated June 8, 1988.

2. Report entitled "Reasons for Decision and Decision" by the Joint Board under The Consolidated Hearings Act, 1981 and all documents and exhibits mentioned therein, dated October 24, 1988.

3. Order in Council dated October 4, 2000 together with Notice of Approval to Proceed with the Undertaking, EA File No. PR-KM-02, both issued under the Environmental Assessment Act.

4. Application for Amendment To Provisional Certificate of Approval, Waste Disposal Site, and supporting information, dated September 11, 2000, signed b J. Pappain.

5. Memorandum from John Chandler, A.J. Chandler & Associates Ltd., on behalf of KMS Peel Inc., dated January 22, 2001.

5. Memorandum from John Chandler, A.J. Chandler & Associates Ltd., on behalf of KMS Peel Inc., dated February 6, 2001.

The reasons for the imposition of these conditions are as follows:

1. The reason for Conditions 1, 13, 16 and 17 is to ensure that the Site is operated in accordance with the application and supporting information submitted by the Company, and not in a manner which the Director has not been asked to consider.

2. The reason for Conditions 2- 5 and 7- 12, inclusive, is to clarify the legal rights and responsibilities of the Company.

3. The reason for Condition 6 is to ensure that the appropriate Ministry staff have ready access to the operations of the Site which are approved under this Certificate. The Condition is supplementary to the powers of entry afforded a Provincial Officer pursuant to the *Environmental Protection Act*, the *Ontario Water Resources Act* and the *Pesticides Act*, as amended.

4. The reason for Conditions 14, 15, 18 - 33 inclusive, and 42 is to ensure that the Site is operated in a manner which does not result in a nuisance or a hazard to the health and safety of the environment or people.

5. The reason for Conditions 34 is to outline the minimum performance requirements considered necessary to prevent an adverse effect resulting from the operation of the Equipment.

6. The reason for Conditions 35 - 39, inclusive, is to require the Company to gather accurate information so that the environmental impact and subsequent compliance with the Act, the Regulations and this Certificate can be verified.

7. The reason for Conditions 40 and 41 is to require the Company to retain records and provide information to the Ministry so that the environmental impact and subsequent compliance with the Act, the Regulation and this Certificate can be verified.

8. The reason for Conditions 43 is to ensure that the local residents are properly informed of the activities at the Site and that their concerns can be heard and acted upon , as necessary.

9. The reason for Conditions 44 - 47, inclusive, is to ensure that staff are properly Trained in the operation of the equipment used at the Site and emergency response procedures. This will minimize the possibility of spills occurring and will enable staff to deal promptly and effectively with any spills that do occur.

10. The reason for Condition 48 is to ensure that sufficient funds are available to the Ministry to clean up the Site in the event that the Company is unable or unwilling to do so.

11. The reason for Condition 49 is to ensure appropriate restitution can take place in the event that operation of the Site results in injury to a person or damage to property.

12. The reason for Condition 50 is included to ensure that any complaints caused by the operation of the Site are addressed in a timely manner and actions taken to prevent any further incidents that may cause complaints.

13. The reason for Condition 51 is to ensure that the Site is closed in accordance with Ministry standards and to protect the health and safety of the public and the environment.

In accordance with Section 139 of the Environmental Protection Act, R.S.O. 1990, Chapter E-19, you may by written notice served upon me and the Environmental Appeal Board ,within 15 days after receipt of this Notice, require a hearing by the Board. Section 142 of the Environmental Protection Act, as amended provides that the Notice requiring a hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

In addition to these legal requirements, the Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the waste disposal site is located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary,
Environmental Appeal Board,
2300 Yonge St., 12th Fl.,
P.O. Box 2382
Toronto, Ontario.
M4P 1E4

The Director,
Section 39, Environmental Protection Act,
Ministry of the Environment,
2 St. Clair Ave. W., 12A Floor,
Toronto, Ontario.
M4V 1L5

DATED AT TORONTO this 30th day of January 2002.

I. Parrott, P. Eng.
Director
Section 39
Environmental Protection Act

Encls.

cc: J. Budz, District Manager, Halton-Peel District Office
Richard Brown, Business & Fiscal Planning Branch
Director, Environmental Monitoring and Reporting Branch
Clerk, The City of Brampton
Clerk, The Regional Municipality of Peel

CONTENT COPY OF ORIGINAL

Ministry of Environment and Energy | Ministère de l'Environnement et de l'Énergie

Ontario

AMENDMENT TO CERTIFICATE OF APPROVAL
AIR
NUMBER 3383-4RKM3Q
Notice No. 2

KMS Peel Inc.
7656 Bramalea Road
Brampton, Ontario
L6T 5M5

Site Location: Lot 14, Concession 4
Lot 14, Concession 4
Brampton City, Regional Municipality Of Peel

You are hereby notified that I have amended Certificate of Approval No. 3383-4RKM3Q issued on February 14, 2001 for an energy-from - waste facility comprising of incinerators, waste heat recovery boilers, steam turbine-generator set, air pollution control trains, control systems for mercury, Nox and Dioxin, continuous emission monitoring system, process controls, bypass duct arrangement, silos, gas turbine generator and plant control system, as follows:, as follows:

- removal of item 13 from the list of equipment approved at site, namely removal of the Taurus 60S T7300 gas turbine generator - page 8 of 9 of the Certificate

- revisions to conditions listed in SCHEDULE 2, SECTION10 as follows:

(4) (a) The 24-hour average concentration of hydrogen chloride in the Undiluted Gases at the outlet of each of the two Air Pollution Control Trains and in the Main Stack, shall be not more than 18 parts per million by volume on dry basis, or 27 milligrams per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25 ^{0}C and a reference pressure of 101.3 kilopascals.

(b) strike reference to (4) (b)

(5) The concentration of suspended particulate matter in the Main Stack shall be not more than17 milligrams per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25 ^{0}C and a reference pressure of 101.3 kilopascals.

(6) The opacity of the gases at the outlet duct of each of the two Air Pollution Control Trains and in the Main Stack, shall be not more than:

(a) 5 percent, calculated as a 2-hour average; and,

(b) 10 percent, calculated as a 6-minute average.

(7) (a) The toxic equivalent concentration of Dioxins and Furans in the Main Stack shall be not more than 80 picograms per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25 ^{0}C and a reference pressure of 101.3 kilopascals.

(b) The toxic equivalent concentration of Dioxins and Furans shall be calculated in accordance with the International Scheme set out in Schedule 3 of the Certificate.

(8) The 24-hour average concentration of oxides of nitrogen in the Main Stack shall be not more than 110 parts per million volume on a dry basis or 207 milligrams per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25 ^{0}C and a reference pressure of 101.3 kilopascals.

(9) The concentration of mercury in the Main Stack shall be not more than 20 micrograms per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25 ^{0}C and a reference pressure of 101.3 kilopascals.

(10) The concentration of cadmium in the Main Stack shall be not more than 14 micrograms per dry cubic metre

normalized to 11 percent oxygen at a reference temperature of 25 ^{0}C and a reference pressure of 101.3 kilopascals.

(11) The concentration of lead in the Main Stack shall be not more than 142 micrograms per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25 ^{0}C and a reference pressure of 101.3 kilopascals.

- the following additional changes to SCHEDULE 2:

(a) strike reference to 1 (21) from SECTION 1 DEFINITIONS- page 2
(b) strike reference to gas turbine in 14 (1) SECTION 2, PERFORMANCE CONDITIONS- page 12
(c) strike reference to gas turbine in 20 (1) SECTION 3, OPERATION AND MAINTENANCE OF THE FACILITIES- page 15
(d) strike 23 which references operating conditions when the turbine was to be serviced-
SECTION 3, OPERATION AND MAINTENANCE OF THE FACILITIES- page 18

all in accordance with the Application for Approval dated January 20, 2002 and a letter dated February 6, 2002, both submitted by KMS Peel Inc. to Ontario Ministry of Environment and Energy and signed by John Pappain.

This Notice shall constitute part of the approval issued under Certificate of Approval No. 3383-4RKM3Q dated February 14, 2001

In accordance with Section 139 of the Environmental Protection Act, R.S.O. 1990, Chapter E-19, as amended, you may by written notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 142 of the Environmental Protection Act, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the works are located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary* Environmental Review Tribunal 2300 Yonge St., 12th Floor P.O. Box 2382 Toronto, Ontario M4P 1E4	AND	The Director Section 9, *Environmental Protection Act* Ministry of Environment and Energy 2 St. Clair Avenue West, Floor 12A Toronto, Ontario M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

The above noted works are approved under Section 9 of the Environmental Protection Act.

DATED AT TORONTO this 7th day of June, 2002

Neil Parrish, P.Eng.
Director
Section 9, *Environmental Protection Act*

AK/
c: District Manager, MOEE Halton-Peel
John Pappain, KMS Peel Inc.

CONTENT COPY OF ORIGINAL

Ontario

Ministry of the Environment | Ministère de l'Environnement

CERTIFICATE OF APPROVAL
AIR
NUMBER 3275-5PASVG

KMS Peel Inc.
7656 Bramalea Road
Brampton, Ontario
L6T 5M5

Site Location: 7656 Bramalea Road
Lot 14, Concession 4
Brampton City, Regional Municipality of Peel, Ontario

You have applied in accordance with Section 9 of the Environmental Protection Act for approval of:

- one (1) Taurus 60S - T7300 in a SoLoNOx configuration, or equivalent, gas turbine generator with a nominal generating capacity of 5.2 megawatts electrical, firing natural gas at a nominal thermal input of 65.3 million kilojoules per hour and exhausting to the atmosphere at a volumetric flow rate of 49 actual cubic metres per second, at an approximate temperature of 485 degrees Celsius, through a stack, having an exit diameter of 1.067 metres, extending 10.97 metres above grade and 2.6 metres above roof, all housed in a separate building adjacent to the energy from waste facility;

all in accordance with the application for a Certificate of Approval (Air), dated June 27, 2003 and signed by Robert Dodds, KMS Peel Inc., and all supporting information associated with the application including additional information provided by A.J. Chandler & Associates Ltd. on behalf of KMS Peel Inc., dated July 16, 2003 and signed by John Chandler, P.Eng.

For the purpose of this Certificate of Approval and the terms and conditions specified below, the following definitions apply:

(1) "Act" means the *Environmental Protection Act*.

(2) "Certificate" means this Certificate of Approval, including Schedules "A" and "B", issued in accordance with Section 9 of the Act.

(3) "Company" means KMS Peel Inc.

(4) "Director" means any Ministry employee appointed by the Minister pursuant to Section 5 of the Act.

(5) "District Manager" means the District Manager, Halton-Peel District Office, Central Region of the Ministry.

(6) "Equipment" means the one (1) combustion turbine described in the Company's application, this Certificate and in the supporting documentation submitted with the application, to the extent approved by this Certificate.

(7) "Facility" means the electric power generation facility comprising the combustion turbine described in the Company's application, this Certificate and in the supporting documentation referred to herein, to the extent approved by this Certificate.

(8) "Fuel Flow Rate" means the flow rate of the fuel, expressed in cubic metres per second at standard temperature and pressure, or kilograms per second.

(9) "Heat Output" means the total useful heat energy recovered from the combustion turbine as heat, expressed in megawatts.

(10) "Lower Heating Value" means the energy released during combustion of the fuel, excluding the latent heat content of the water vapour component of the products of combustion, expressed in megajoules per cubic metre at standard

temperature and pressure, or megajoules per kilogram.

(11) "Manager" means the Manager, Technology Standards Section, Standards Development Branch of the Ministry, or any other person who represents and carries out the duties of the Manager, as those duties relate to the conditions of this Certificate.

(12) "Manual" means a document or a set of documents that provides written instructions to staff of the Company.

(13) "Ministry" means Ontario Ministry of the Environment.

(14) "Power Output" means the electricity and shaft power production of the combustion turbine, expressed in megawatts.

(15) "Pre-Test Information" means the information outlined in Section 1 of the Source Testing Code.

(16) "Reference Conditions" means a reference state of 15 degrees Celsius ambient temperature, 60 percent relative humidity and 101.3 kilopascals barometric pressure.

(17) "Source Testing" means sampling and testing to measure the emissions of nitrogen oxides, carbon monoxide and sulphur dioxide from the Facility/Equipment at maximum rating of the Facility/Equipment or at the maximum load achievable at the time of testing.

(18) "Source Testing Code" means the Source Testing Code, Version 2, Report No. ARB-66-80, dated November 1980, prepared by the Ministry, as amended.

(19) "Thermal Efficiency" means the Thermal Efficiency of the Facility calculated according to the formula described in Schedule "B" attached to this Certificate.

You are hereby notified that this approval is issued to you subject to the terms and conditions outlined below:

TERMS AND CONDITIONS

PERFORMANCE

1. The Company shall ensure that the Facility is designed and operated to comply, at all times, with the following performance requirements:

(i) The concentrations of nitrogen oxides, carbon monoxide and sulphur dioxide in the undiluted flue gas leaving the combustion turbine are not greater than the limits specified in Schedule "A" of this Certificate.

(ii) The thermal efficiency of the Equipment is not less than the efficiency specified in Schedule "A" of this Certificate.

SOURCE TESTING

2. The Company shall perform Source Testing, after commissioning of the Equipment and thereafter every two (2) calender years, to determine the rates of emission of nitrogen oxides, carbon monoxide and sulphur dioxide from the Equipment. Three (3) source tests shall be conducted at the time of testing.

3. The Company shall submit, not later than three (3) months from the date of this Certificate, to the Manager a test protocol, including the Pre-Test Information for the Source Testing required by the Source Testing Code.

4. The Company shall finalize the test protocol in consultation with the Manager.

5. The Company shall not commence Source Testing until the Manager has accepted the test protocol.

6. The Company shall complete the Source Testing not later than three (3) months after the Manager has accepted the test protocol and thereafter every two (2) calender years.

7. The Company shall notify the District Manager and the Manager, in writing, of the location, date and time of any impending Source Testing required by this Certificate, at least ten (10) business days prior to the Source Testing.

8. The Company shall submit a report on the Source Testing to the District Manager and the Manager not later than three (3) months after completing the Source Testing. The report shall be in the format described in the Source Testing Code, and shall also include:

(i) an executive summary;

(ii) date, time and duration of each test;

(iii) ambient air temperature, barometric pressure and relative humidity during test;

(iv) the oxygen (% by volume) concentration and stack gas volumetric flow rate (cubic metres per second at Reference Conditions);

(v) emission concentrations of nitrogen oxides, carbon monoxide and sulphur dioxide (in ppmv @ 15% O_2);

(vi) stack gas temperature (degrees Celsius);

(vii) average of emission concentration readings (ppmv @ 15% O_2) for the 3 tests conducted.

9. The Director may not accept the results of the Source Testing if:

(i) the Source Testing Code or the requirements of the Manager were not followed; or

(ii) the Company did not notify the District Manager and the Manager of the Source Testing; or

(iii) the Company failed to provide a complete report on the Source Testing.

10. If the Director does not accept the results of the Source Testing, the Director may require re-testing.

OPERATION AND MAINTENANCE

11. The Company shall ensure that the Facility is properly operated at all times as follows:

(i) The Company shall:

> (a) prepare, not later than three (3) months after the commencement of operation of the Facility and update, as necessary, a Manual outlining the operating procedures and a maintenance program for the Facility, including the procedures to record and respond to environmental complaints;
>
> (b) implement the recommendations of the operating and maintenance Manual.

(ii) The Company shall perform a test, when the Source Testing is conducted, to determine the Thermal Efficiency of the Equipment.

(iii) The Company shall:

> (a) determine, as a minimum, the parameters described in Schedule "B" of this Certificate, during the Thermal Efficiency testing for the Equipment;
>
> (b) calculate the Thermal Efficiency of the Equipment according to the formula described in Schedule "B" of this Certificate;
>
> (c) prepare a summary on the results of the Thermal Efficiency testing no later than three (3) months after completing the test. The summary shall indicate the thermal efficiency of the Equipment and include all

parameters described in Schedule "B" of this Certificate.

(d) if the measured thermal efficiency is less than the anticipated thermal efficiency specified in Schedule "B" of this Certificate (with a tolerance of 0.05 multiplied by the anticipated thermal efficiency), notify the Ministry so that the concentration limits specified in Schedule "A" of this Certificate could be revised accordingly.

RECORD RETENTION

12. The Company shall retain, for a minimum of two (2) years from the date of their creation, all records and information related to or resulting from the maintenance, testing, monitoring and recording activities required by this Certificate. These records shall be made available to staff of the Ministry upon request. The Company shall retain, as a minimum:

(i) all records on the dates and times of operation of the Facility;

(ii) all records on the maintenance, repair and inspection of the Facility;

(iii) all records and summaries produced from the source testing and thermal efficiency testing;

(iv) all records on the environmental complaints;

(v) all records on the equipment upset/malfunction.

SCHEDULE "A"

PARAMETER	LIMIT
Nitrogen Oxides	39.6 ppmv [1]
Carbon Monoxide	60 ppmv [1]
Sulphur Dioxide	94.8 ppmv [1]
Thermal Efficiency	28 percent

NOTE:

1. "ppmv" means parts per million by volume on a dry basis normalized to 15 percent oxygen on an hourly basis.

SCHEDULE "B"

PARAMETERS:

1. Power Output

2. Fuel Flow Rate

3. Lower Heating Value

4. (a) Ambient air temperature (expressed in degree of Celsius)
(b) barometric pressure (expressed in kilopascal)
(c) relative humidity (expressed in per cent)

5. Date, time and duration of test.

FORMULA:

(Power Output + Heat Input) x 100%
Thermal Efficiency = --
Fuel Flow Rate x Lower Heating Value

NOTE:

Thermal Efficiency testing should be conducted at maximum rating or at the maximum load achievable at the time of testing and shall employ an averaging time of not less than three hours.

The reasons for the imposition of these terms and conditions are as follows:

1. Condition 1 is included to provide the minimum performance requirements considered necessary to prevent an adverse effect resulting from the operation of the Facility.

2. Conditions 2 to and including 10 are included to require the Company to gather accurate information so that the environmental impact and subsequent compliance with the Act, the regulations and this Certificate can be verified.

3. Condition 11 is included to emphasize that the Facility must be maintained and operated according to a procedure that will result in compliance with the Act, the regulations and this Certificate.

4. Condition 12 is included to assist the Ministry in determining whether or not the Facility is being operated and maintained, and the contaminant emissions and thermal efficiency are being monitored, as required by this Certificate.

In accordance with Section 139 of the Environmental Protection Act, R.S.O. 1990, Chapter E-19, as amended, you may by written notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 142 of the Environmental Protection Act, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the works are located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

CONTENT COPY OF ORIGINAL

The Secretary* Environmental Review Tribunal 2300 Yonge St., 12th Floor P.O. Box 2382 Toronto, Ontario M4P 1E4	AND	The Director Section 9, *Environmental Protection Act* Ministry of Environment and Energy 2 St. Clair Avenue West, Floor 12A Toronto, Ontario M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

The above noted works are approved under Section 9 of the Environmental Protection Act.

DATED AT TORONTO this 21st day of July, 2003

Neil Parrish, P.Eng.
Director
Section 9, *Environmental Protection Act*

RW/
c: District Manager, MOE Halton-Peel District Office
A. John Chandler, P.Eng., A.J. Chandler & Associates Limited

Ministry of the Environment
Ministère de l'Environnement
Ontario

AMENDMENT TO CERTIFICATE OF APPROVAL
AIR
NUMBER 3383-4RKM3Q
Notice No. 1
Issue Date: June 12, 2006

Algonquin Power Energy From Waste Inc.
2845 Bristol Circle
Oakville, Ontario
L6H 7H7

Site Location: 7656 Bramalea Road
Lot 14, Concession 4
Brampton City, Regional Municipality of Peel, Ontario

You are hereby notified that I have amended Certificate of Approval No. 3383-4RKM3Q issued on February 14, 2001 for an energy-from-waste facility to produce electricity utilizing municipal solid waste, containing domestic, commercial and solid non-hazardous industrial waste, as a fuel, as follows:

Revoke existing items 6, 8.c, and 10 in the preamble of the Certificate and replace with the corresponding items as listed below:

6. One Mercury Control System, consisting of:

Two (2) NORIT Porta-PAC™ powdered activated carbon injection systems to supply powdered activated carbon to the two venturi reactors of the APC system to control emissions of mercury in the exhaust gases from the five Incinerators. Each system is complete with:

i. one positive displacement air blower;
ii. a chute adapter to connect the Super Sack to the feeder hopper;
iii. a feeder hopper with a capacity of 0.085 cubic metre located on the volumetric feeder;
iv. a volumetric screw type feeder to accurately dispense PAC to the eductor;
v. an eductor that utilizes a venturi principle to mix PAC into the pneumatic transport air stream;
vi. a calibration system for the feeder set to pounds per hour of PAC;
vii. a controller system for the feeder screw to control dosing rate;
viii. associated sensors and alarms to ensure that the operation is maintained; and
ix. pneumatic transport and injection lances in the venturi reactor of the APC system.

8.c. two (2) in-situ Laser monitors, installed, operated and maintained in accordance with manufacturer's specifications, to measure the concentration of hydrogen chloride in the flue gases at the exit of each of the two (2) baghouses, each system consisting of:

i. A NEO Laser II HCl monitor consisting of a transmitter and receiver mounted on stack flanges;
ii. A NEO calibration cell installed in front of the receiver unit; and
iii. Suitable tubes to provide purge air to the monitor and calibration gas to the calibration cell.

The LaserGas II monitors are based on tuneable diode lasers (TDL), the laser beam being sent through a measurement volume from a transmitter comprising a laser to a receiver with a light sensitive detector. The instrumentation is protected from the process gas using windows that are kept clean by purge air. Automatic correction for temperature and pressure in the system is included.

10. a bypass duct complete with a double bladed isolating damper and heated air circulation system, located ahead of the Air Pollution Control Trains and the NOx and Dioxin Control System, directing the flue gases from the five Incinerators into the Bypass Stack extending 35.18 metres above grade with an inside exit diameter of 1.65 metres, exhausting to the

atmosphere at a normal volumetric rate of 50.25 actual cubic metres per second at 165 degrees Celsius;

Revoke existing definitions (9), (26) and (29)(i) in the "DEFINITIONS" Section in Schedule 2 of the Certificate and replace with the corresponding definitions as listed below:

(9) "Company" means Algonquin Power Energy From Waste Inc. and includes its sucessors and assignees;

(26) "Mercury Control System" means a powdered activated carbon injection system as described in item 6 of the preamble of the Certificate;

(29)(i) the powdered activated carbon feed rate to the injection lances;

Revoke existing Terms and Conditions 10(2) and 46 in Schedule 2 of the Certificate and replace with the revised Terms and Conditions 10(2) and 46 as listed below:

10.(2) The 4-hour average concentration of carbon monoxide in the Undiluted Gases at the outlet of the secondary chamber of each of the five Incinerators shall be not more than 35 parts per million by volume on dry basis normalized to 11 percent oxygen at a reference temperature of 25oC and a reference pressure of 101.3 kilopascals, and 49 milligrams per dry cubic metre (or 43 ppm) normalized to 11 percent oxygen at a reference temperature of 25oC and a reference pressure of 101.3 kilopascals as measures in the Main Stack.

46. The Company shall prepare an annual report on the operation of the Facilities, and submit the said report to the District Manager not later than February 1st of each year covering the previous twelve-month period ending December 31st. Each report shall include, but not be limited to the following:

All in accordance with the Application for Approval (Air & Noise), dated December 2, 2005 and revised December 23, 2005 and signed by R. Dodds, and all supporting information and documentation associated with the application including additional information provided by John Chandler of A.J. Chandler & Associates on behalf of Algonquin Power Energy From Waste Inc., contained in an email sent March 10, 2006 to Rudolf Wan, P.Eng., Ontario Ministry of the Environment.

This Notice shall constitute part of the approval issued under Certificate of Approval No. 3383-4RKM3Q dated February 14, 2001.

All Terms and Conditions as outlined in the Certificate of Approval 3383-5RKM3Q dated February 14, 2001 apply to this Notice.

In accordance with Section 139 of the Environmental Protection Act, R.S.O. 1990, Chapter E-19, as amended, you may by written notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 142 of the Environmental Protection Act, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the works are located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary* Environmental Review Tribunal 2300 Yonge St., Suite 1700 P.O. Box 2382 Toronto, Ontario M4P 1E4	AND	The Director Section 9, *Environmental Protection Act* Ministry of the Environment 2 St. Clair Avenue West, Floor 12A Toronto, Ontario M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

The above noted works are approved under Section 9 of the Environmental Protection Act.

DATED AT TORONTO this 12th day of June, 2006

Victor Low, P.Eng.
Director
Section 9, *Environmental Protection Act*

RW/
c: District Manager, MOE Halton-Peel District Office
John Chandler, A.J. Chandler & Associates Ltd.

Ministry of the Environment / Ministère de l'Environnement

Ontario

AMENDMENT TO PROVISIONAL CERTIFICATE OF APPROVAL
WASTE DISPOSAL SITE
NUMBER 4591-56VSTN
Notice No. 4
Issue Date: February 20, 2007

Algonquin Power Energy From Waste Inc.
2845 Bristol Circle
Oakville, Ontario
L6H 7H7

Site Location: Algonquin Power Energy From Waste Facility
7656 Bramalea Rd
Brampton City, Regional Municipality Of Peel
L6T 5M5

You are hereby notified that I have amended Provisional Certificate of Approval No. 4591-56VSTN issued on January 30, 2002 for a Waste Disposal Site (Incineration), complete with an Energy from Waste Facility and associated equipment, as also referenced in the Order in Council dated October 4, 2000 together with Notice of Approval to Proceed with the Undertaking, EA File No. PR-KM-02, under the Environmental Assessment Act , as follows:

1. The following paragraph in the preamble of the Certificate has been deleted:

   "solid non-hazardous waste from domestic, commercial and industrial sources, all collected within the Regional Municipalities of Halton, Peel, Durham and York as well as The Corporation of The City of Toronto, including solid non-hazardous waste collected at the Pearson International Airport originating from food service establishments as well as aircraft and airside areas, including Canada Customs",

   and replaced by the following paragraph:

   "solid non-hazardous waste from domestic, commercial and industrial sources, all collected within the Regional Municipality of Peel as well as solid non-hazardous waste from industrial, commercial and institutional sources within The Corporation of The City of Toronto and the Regional Municipalities of Halton, Durham and York, and solid non-hazardous waste, limited to International Waste, collected at the Pearson International Airport, the Port of Toronto, the Hamilton International Airport or the Port of Hamilton all in Ontario."

2. Condition number 13 is deleted and replaced by the following:

   "The Company shall not Receive waste that has been generated or has been previously transferred to any facility in Ontario from outside The Regional Municipality of Peel, except for solid non-hazardous waste from industrial, commercial and institutional sources within The Corporation of The City of Toronto and The Regional Municipalities of Halton, Durham and York as well as solid non-hazardous waste, limited to International Waste, collected at the Pearson International Airport, the Hamilton International Airport, the Port of Toronto or the Port of Hamilton all located in Ontario."

3. The following condition number 14.a is added:

   "The Company shall handle, transport, store, and dispose of all International Waste in accordance with the Health of Animals Regulations, C.R.C., c 296. and in accordance with Company's document entitled "WSD Operating Procedures, Handling of International Waste (IW), Procedure # 04-07001, Revision # 4, dated February 2, 2007."

4. The following definitions are added:

   "Aircraft Garbage" means garbage that contains or is suspected of containing an animal product or an animal by-product and that originated in food that was taken on board an aircraft and was served or intended to be served for consumption on the aircraft by the passengers or crew of the aircraft en route to Canada;

   "International Waste" means Aircraft Garbage, Ship's Refuse and Seized Materials;

   "Seized Materials" means materials that contain or are suspected of containing an animal or plant product or byproducts that do not meet import requirements and are seized from passengers at the point of entry to Canada by staff of the Canada Border Services Agency;

   "Ship's Refuse" means waste that contains or is suspected of containing an animal product or an animal by-product and that originated in food that was taken on board a vessel and was served or intended to be served for consumption on the vessel by the passengers or crew of the vessel en route to Canada;

all in accordance with the application dated December 21, 2006, signed by Ford Scissons and supporting information and documentation prepared by John Chandler of A.J. Chandler & Associates Ltd. on behalf of Algonquin Power Energy From Waste Inc..

This Notice shall constitute part of the approval issued under Provisional Certificate of Approval No. 4591-56VSTN dated January 30, 2002.

In accordance with Section 139 of the Environmental Protection Act, R.S.O. 1990, Chapter E-19, as *amended, you may by written notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 142 of the Environmental Protection Act, provides that the Notice requiring the hearing shall state:*

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the waste disposal site is located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary* Environmental Review Tribunal 2300 Yonge St., Suite 1700 P.O. Box 2382 Toronto, Ontario M4P 1E4	AND	The Director Section 39, *Environmental Protection Act* Ministry of the Environment 2 St. Clair Avenue West, Floor 12A Toronto, Ontario M4V 1L5

* **Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

The above noted waste disposal site is approved under Section 39 of the Environmental Protection Act.

DATED AT TORONTO this 20th day of February, 2007

Tesfaye Gebrezghi, P.Eng.
Director
Section 39, *Environmental Protection Act*

AP/

c: District Manager, MOE Halton-Peel
Ford Scissons, Algonquin Power Energy From Waste Inc.

APPENDIX E-2

Plasco Energy-From-Waste Demonstration Facility, Ottawa, ON

Ministry of the Environment **Ministère de l'Environnement**

Ontario

CERTIFICATE OF APPROVAL
AIR
NUMBER 6925-6REN9E
Issue Date: December 1, 2006

PLASCO Trail Road Inc.
1145 Innovation Drive, Suite 100
Kanata, Ontario
K2K 3G8

Site Location: Nepean Landfill Site (Closed)
Part of Lot 9, Concession 4, Rideau Front
Ottawa City, Ontario

You have applied in accordance with Section 9 of the Environmental Protection Act for approval of:

one (1) Energy-From-Waste Demonstration Facility, to process and convert non-hazardous *Municipal Waste* up to a maximum of 75 tonnes per day and *High Carbon Waste* up to a maximum of 10 tonnes per day, employing the Plasma Gasification technology, to a Synthetic Gas or Syngas and a solid residue called slag, consisting of the following plants and associated equipment:

- one (1) enclosed Materials Handling Building, used for the receipt, sorting and shredding by an electrically operated shredder of incoming *Municipal Waste*;

- one (1) Plastics Storage Building, closed on three (3) sides, used for the receipt and shredding by an electrically operated shredder of incoming *High Carbon Waste*;

- one (1) Processing Plant, where the shredded *Municipal Waste* mixed if required with a predetermined proportion of *High Carbon Waste* is fed through an enclosed conveyor to the Converter, in which the wastes are processed by the Plasma Gasification technology to produce the Synthetic Gas (Syngas) and the inert slag. The Syngas exits the Converter to the Gas Quality Control Suite (GQCS) for cooling and cleaning and the slag is vitrified in the slag chamber of the Converter. The GQCS consists of:

  Syngas Stream, in sequence:

  - one (1) evaporative cooler, to cool the Syngas from about 1,000 degrees Celsius to about 175 to 300 degrees Celsius by direct injection of water,

  - one (1) activated carbon dry injection system, to inject activated carbon and/or feldspar into the Syngas to reduce mercury and dioxins and to prevent build-up of tars,

- one (1) baghouse, to remove suspended particulate matter and activated carbon from the Syngas, equipped with filter bags, nitrogen gas reverse pulse jet cleaning mechanism, having a filtration area of 314 square metres,

- one (1) packed bed scrubber, to control hydrogen chloride in the Syngas, having an inside diameter of 1.37 metres and a height of 8.93 metres, equipped with a mist eliminator and 3.68 cubic metres of glass filled polypropylene as packing to a packing height of 3.0 metres, using sodium hydroxide solution as scrubbing solution,

- one (1) activated carbon bed filter, used to further remove mercury from the Syngas, consisting of one (1) single vessel of granular sulphur impregnated activated carbon, having an inside diameter of 3.0 metres, containing 4,625 kilograms of granular activated carbon to a depth of 1.07 metres, and

- one (1) hydrogen sulphide removal system, employing the Shell Paques Biological technology, comprising:

    - one (1) packed bed bioscrubber, having an inside diameter of 1.83 metres, equipped with a mist eliminator and packing of 1.5-inch diameter polypropylene Pall rings to a height of 7.3 metres, using an alkaline solution as scrubbing solution. The Syngas exits the bioscrubber to a storage vessel for temporary storage, to be fed either to the Power Plant or the enclosed flare described below. A sulphide-containing solution exits the bioscrubber and is fed to the sulphur recovery bio-reactor described below,

    - one (1) aerated bio-reactor, where the sulphur in solution is oxidized by bacteria to elemental sulphur which is further filtered in a filter press and sterilized,

Slag Stream, in sequence:

- one (1) baghouse, used for suspended particulate matter control of the gas from the slag chamber of the Converter. The baghouse is equipped with filter bags, nitrogen gas reverse pulse jet cleaning mechanism, having a total filtration area of 5 square metres,

- one (1) activated carbon filter, used to remove mercury from the gas, consisting of one (1) single vessel of granular sulphur impregnated activated carbon, having an inside diameter of 0.76 metre, containing 286 kilograms of granular activated carbon to a depth of 1.07 metres. The gas from this activated carbon filter is directed to the inlet of the baghouse serving the Syngas stream;

- one (1) enclosed flare, used to combust the cooled and cleaned Syngas exiting the GQCS before the *Facility* achieved operational stabilization or under abnormal operation, exhausting into the atmosphere at a total maximum volumetric flow rate of 10.4 actual cubic metres per second, through two (2) identical stacks, each having an exit diameter of 0.922 metre, extending 8.8 metres above grade;

- one (1) Power Plant, consisting of six (6) internal combustion reciprocating engines, firing on the cooled and cleaned Syngas exiting the storage tank after the GQCS above, each engine having a power rating of 720 kilowatts, each exhausting into the atmosphere at a maximum volumetric flow rate of 1.33 actual cubic metres per second at an approximate temperature of 515 degrees Celsius, each through its own stack, having an exit diameter of 0.25 metre, extending 10 metres above grade. The power generated in the Power Plant is fed to the grid; and

- one (1) induced draft, cross-flow cooling tower, single cell design, exhausting into the atmosphere at a maximum volumetric flow rate of 59.5 cubic metres per second through a stack, having an exit diameter of 3.05 metres, extending 9.15 metres above grade.

The *Facility* shall receive and process *Municipal Waste* and *High Carbon Waste* up to two (2) years from the *Start-up Date*;

all in accordance with the Application for Approval (Air & Noise), dated June 16, 2006 and received June 23, 2006 and signed by Ken Campbell, PLASCO Trail Road Inc., and all supporting information and documentation associated with the application including additional information provided by PLASCO Trail Road Inc. contained in emails sent July 12, 2006 and July 19, 2006 from Pascale Marceau, P.Eng. to Rudolf Wan, P.Eng., Ontario Ministry of the Environment, and additional information provided by SENES Consultants Limited on behalf of PLASCO Trail Road Inc., dated August 15, 2006 and September 22, 2006 and signed by Richard Urbanski.

For the purpose of this Certificate of Approval and the terms and conditions specified below, the following definitions apply:

(1) "*Act*" means the *Environmental Protection Act*.

(2) "*Activated Carbon Filters*" means the one (1) activated carbon filter for Syngas treatment and the one (1) activated carbon filter for the treatment of gas from the slag chamber.

(3) "*AERMOD*" means the dispersion model developed by the American Meteorological Society/U.S. Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC) including the PRIME (Plume Rise Model Enhancement) algorithm, used to calculate one-hour and 24-hour average concentrations of a contaminant at the *Point of Impingement*.

(4) "*CEM System*" means the continuous emission monitoring system as described in the *Company*'s application, this *Certificate* and in the supporting documentation referred to herein.

(5) "*Certificate*" means this Certificate of Approval, including Schedule "A", "B", "C", "D" "E" and "F" issued in accordance with Section 9 of the *Act*.

(6) "*Certificate of Approval (Waste)*" means the corresponding Provisional Certificate of Approval (Waste Disposal Site) number 3166-6TYMDZ issued to the *Company*, under section 39 of the *Act*.

(7) "*Cessation of Discharges Protocol*" means the cessation of discharges protocol specified in sub-section 13(2) of *O. Reg. 254/06* made under the *Act*.

(8) "*Company*" means PLASCO Trail Road Inc. and includes any of its successors and assigns and any person related to PLASCO Trail Road Inc. by ownership.

(9) "*Director*" means any *Ministry* employee appointed in writing by the Minister pursuant to section 5 of the *Act*.

(10) "*District Manager*" means the District Manager, Ottawa District Office, Eastern Region of the *Ministry*.

(11) "*Equipment*" means all the equipment in the GQCS, the reciprocating engines in the Power Plant and the enclosed flare described in the *Company*'s application, this *Certificate* and in the supporting documentation submitted with the application, to the extent approved by this *Certificate*.

(12) "*Exhausted*" means the capacity of the activated carbon in either one of the *Activated Carbon Filters* to adsorb emissions is reached and that carbon filter is no longer able to effectively reduce emissions.

(13) "*High Carbon Waste*" means residual municipal waste from waste recycling facilities including but not necessarily limited to Types 3, 4, 5, 6 and 7 plastics and shredded tires to the extent described in Section 7(b) and 7(c) of *O. Reg. 254/06*.

(14) "*Facility*" means the Energy-From-Waste Demonstration Facility described in the *Company*'s application, this *Certificate* and in the supporting documentation submitted with the application, to the extent approved by this *Certificate*.

(15) "*Manager*" means the Manager, Technology Standards Section, Standards Development Branch of the *Ministry*, or any other person who represents and carries out the duties of the Manager, as those duties relate to the conditions of this *Certificate*.

(16) "*Manual*" means a document or a set of documents that provide written instructions to staff of the *Company*.

(17) "*Ministry*" means the Ontario Ministry of the Environment.

(18) "*Municipal Waste*" means municipal waste as defined in *O. Reg. 347* to the extent described in section 7(a) of *O. Reg. 254/06* and Condition 28(a) in the *Certificate of Approval (Waste)*.

(19) "*O. Reg. 254/06*" means the Ontario Regulation 254/06: PLASCO Demonstration Project made under the *Act*.

(20) "*O. Reg. 347*" means Regulation 347, R.R.O. 1990, made under the *Act*, as amended from time to time.

(21) "*Odour Control Plan*" means a document or a set of documents that provide written instructions to staff of the *Company* to minimize the generation and control of odour from all potential sources in the *Facility*.

(22) "*Point of Impingement*" means any point in the natural environment. The point of impingement for the purposes of verifying compliance with the *Act* shall be chosen as the point located outside the *Company*'s property boundaries at which the highest concentration is expected to occur, when that concentration is calculated in accordance with *AERMOD*, or any other method accepted by the Director.

(23) "*Pre-Test Information*" means the information outlined in Section 1 of the *Source Testing Code*.

(24) "*Start-up Date*" means the date when *Municipal Waste* or *High Carbon Waste* is first received at the *Facility*, whichever occurs earlier.

(25) "*Source Testing*" means sampling and testing to measure emissions resulting from operation of the flare or the reciprocating engines under conditions which yield the worst case emissions within the approved operating range of the *Facility*.

(26) "*Source Testing Code*" means the Source Testing Code, Version 2, Report No. ARB-66-80, dated November 1980, prepared by the *Ministry*, as amended.

(27) "*Test Contaminants*" means particulate matter, lead, cadmium, mercury, dioxins and furans, the polyaromatic hydrocarbons contained in Schedule "C" and the volatile organic compounds contained in Schedule "D" of this *Certificate*.

You are hereby notified that this approval is issued to you subject to the terms and conditions outlined below:

TERMS AND CONDITIONS

NOTIFICATION OF FACILITY START-UP

1. The *Company* shall notify the *Director* and the *District Manager* in writing the *Start-up Date* of the *Facility* not later than fifteen (15) days after that date.

PERFORMANCE REQUIREMENTS

2. The *Company* shall ensure that the *Facility* is designed and operated to comply, at all times, with the following performance requirements:

Maximum Limits

(1) The concentrations of nitrogen oxides, hydrogen chloride, sulphur dioxide, particulate matter, organic matter, mercury, cadmium, lead and dioxins and furans in the undiluted gases emitted from the stacks of the reciprocating engines in the Power Plant or the stacks of the enclosed flare are not greater than the emission limits specified in Schedule "A" of this *Certificate*. The concentrations of these contaminants shall be normalized to 11 percent oxygen at a reference temperature of 25 degrees Celsius and a reference pressure of 101.3 kilopascals. The toxic equivalent concentration of dioxins and furans shall be calculated using the toxicity equivalence factors recommended by the International Scheme as set out in Schedule "F" of this *Certificate*.

3. The *Company* shall not permit the granular activated carbon in either one of the *Activated Carbon Filters* to be *Exhausted* at any time during the operation of the *Facility*.

OPERATION AND MAINTENANCE

4. The *Company* shall ensure that the *Facility* and the *Equipment* are properly operated and maintained at all times. The *Company* shall:

(1) prepare, before commencement of operation of the *Facility*, and update, as necessary, a *Manual* outlining the operating procedures and a maintenance program for the *Facility* and the *Equipment*, including:

(a) routine operating and maintenance procedures in accordance with good engineering practices and as recommended by the *Equipment* suppliers,

(b) frequency of inspection of the scrubbers,

(c) frequency of monitoring the emissions from the *Activated Carbon Filters* and criteria to replace the activated carbon in the *Activated Carbon Filters*,

(d) a staffing plan,

(e) procedures for any record keeping activities relating to operation and maintenance of the *Equipment*,

(f) all appropriate measures to minimize noise, dust and odourous emissions from all potential sources,

(g) complaint handling procedures,

(h) contingency plans and emergency procedures, and

(i) a closure plan;

(2) implement the recommendations of the *Manual*;

(3) make the *Manual* available for inspection by staff of the *Ministry* at any time upon presentation of credentials;

(4) prepare, implement and update as necessary, an *Odour Control Plan* for the Facility;

(5) ensure that funding, staffing, training of staff, process controls, quality assurance and quality control procedures of or in relation to the *Facility* are adequate to achieve compliance with this *Certificate*;

(6) ensure that equipment, material and spare parts, of equal or better quality and specifications, are kept on hand and in good repair for immediate use in the event of:

(a) a breakdown of the *Facility* or any part of the *Facility*,

(b) any change in process parameters which may result in a discharge into the natural environment of any contaminant in an amount, concentration or level in excess of that prescribed by the regulations or imposed by this *Certificate*,

(c) any fire or explosion, and

(d) any other potential contingency,

and that staff are trained in the use of said equipment, material and spare parts and in the methods and procedures to be employed upon the occurrence of such an event.

5. The *Company* shall keep all doors in the Materials Handling Building of the *Facility* fully closed, except when being used for necessary personnel or vehicle entrance and exit, whenever there are wastes stored inside the building.

MONITORING

6. The *Company* shall monitor the emissions and operation of the *Facility* as follows:

Continuous Emission Monitoring

(1) The *Company* shall install and maintain operational a *CEM System*, before the *Start-up Date* of the *Facility*, to continuously monitor and record the temperature and the concentrations of carbon monoxide, oxygen, nitrogen oxides, hydrogen chloride, sulphur dioxide and organic matter in the undiluted flue gases leaving the reciprocating engines stacks or the flare stacks. The locations and specifications of the *CEM System* are outlined in Schedule "E".

(2) The *Company* shall install and operate the *CEM System* in accordance with the following:

(a) during the initial start-up stage of the *Facility* when the Power Plant is not operated, continuously monitor and record the temperature and the concentrations of carbon monoxide, oxygen, nitrogen oxides, hydrogen chloride, sulphur dioxide and organic matter in the undiluted flue gases leaving the two (2) flare stacks. The *Company* shall establish representation of one single stack in terms of emissions monitoring,

(b) when the Power Plant is operated and the enclosed flare is put on standby, continuously monitor and record the temperature and the concentrations of carbon monoxide, oxygen, nitrogen oxides, hydrogen chloride, sulphur dioxide and organic matter in the undiluted flue gases leaving the reciprocating engine stacks. The *Company* shall establish representation of one single stack in terms of emissions monitoring, and

(c) when both the enclosed flare and the Power Plant are in operation, the discharge of the flare and of the Power Plant shall be monitored by the *CEM System* to provide a reading at a minimum of every 15 minutes as per Report EPS 1/PG/7 published by Environment Canada.

(3) The *Company* shall, if the concentrations of mercury and particulate matter are not source-tested in accordance with condition 7(4) below, install and maintain operational a *CEM System* to monitor continuously and to record the concentrations of mercury and particulate matter in the undiluted flue gases leaving the reciprocating engines stacks or the flare stacks.

Source Testing

(4) The *Company* shall perform *Source Testing* to determine the rates of emission of the *Test Contaminants* from the reciprocating engine stacks and the flare stacks. The *Source Testing* shall be conducted at maximum rating or at the maximum load achievable at the time of testing. Each test set shall consist of three (3) separate tests for each contaminant to be tested. The *Source Testing* shall be conducted under different operating scenarios of the *Facility* as follows:

(a) Scenario 1: the feed to the Converter is all *Municipal Waste*,

(b) Scenario 2: the feed to the Converter is majority *Municipal Waste* with about 3 - 5% by weight of the feed *High Carbon Waste* consisting primarily of recycled plastic rejects, and

(c) Scenario 3: the feed to the Converter is majority *Municipal Waste* with about 3 - 5% by weight of the feed *High Carbon Waste* consisting primarily of shredded tires.

(5) The *Company* shall submit to the *Manager*, within one (1) month after the *Start-up Date* of the *Facility*, a test protocol, including the *Pre-Test Information* for the *Source Testing* required by the *Source Testing Code*. The *Company* shall finalize the test protocol in consultation with the *Manager*.

(6) The *Company* shall complete the *Source Testing* after the *Manager* has accepted the test protocol either in accordance with the following schedule or as directed or agreed by the *District Manager*:

(a) not later than three (3) months after the *Start-up Date* of the *Facility*, when all the discharge is through the flare stacks, for all the operating scenarios described in condition 7(4) above,

(b) not later than six (6) months after the *Start-up Date* of the *Facility*, when all the discharge is through the reciprocating engine stacks, for all the operating scenarios described in condition 7(4) above.

(7) The *Company* shall notify the Director, *District Manager* and the *Manager* in writing of the location, date and time of any impending *Source Testing* required by this *Certificate*, at least five (5) business days prior to the *Source Testing*.

(8) The *Company* shall prepare and submit interim and final reports on the *Source Testing* to the Director, *District Manager* and the *Manager* in accordance with the following schedule:

(a) whenever *Source Testing* of the discharge through the reciprocating engine stacks or the flare stacks under any one of the operating scenarios described in condition 7(4) above is conducted, the *Company* shall prepare an interim report on the results of the *Source Testing*, and submit the report not later than one (1) month after the *Source Testing* is completed to the Director, *District Manager* and the *Manager*. The interim report shall be in the format described in the *Source Testing Code*, and shall include the following:

(i) date and time when the *Source Testing* was conducted,

(ii) all records of the operating conditions of the *Facility* at the time of the *Source Testing*, including the type and feed rate of wastes fed to the Converter, operating conditions of the equipment in the GQCS, average and maximum mass flow rate of Syngas feeding to the flare and the reciprocating engines,

(iii) all records of the *CEM System* at the time of the *Source Testing*,

(iv) all results and average of the three (3) source tests for each contaminant obtained during the *Source Testing*, and

(v) the results of dispersion calculations in accordance with *AERMOD* or any other method accepted by the Director indicating the maximum concentrations of the *Test Contaminants* at the *Point of Impingement*,

(b) when all *Source Testing* required under this *Certificate* is completed, the *Company* shall prepare a final report on all the results obtained in the *Source Testing*. The final report shall be prepared and submitted to the Director, *District Manager* and the *Manager* within three (3) months after the last test of the *Source Testing* is completed. This final report shall be in the format described in the *Source Testing Code*, and shall include the following:

(i) an executive summary,

(ii) dates and times when all the tests in the *Source Testing* were conducted,

(iii) a summary of all the operating conditions of the *Facility* at the times of the *Source Testing*,

(iv) a summary of all the records of the *CEM System* at the times of the *Source Testing*,

(v) a summary of all the results obtained at the times of the *Source Testing*,

(vi) a summary table that compares the results of the *Source Testing* and the records obtained by the *CEM System* during the times of the *Source Testing* to the maximum limits contained in Schedule "A" and the operational limits contained in Schedule "B" of this *Certificate*, and

(vii) the results of dispersion calculations, using the maximum of the averaged concentrations of the *Test Contaminants* obtained in the *Source Testing*, in accordance with *AERMOD* or any other method accepted by the Director indicating the maximum concentrations of the *Test Contaminants* at the *Point of Impingement*.

(9) The Director may not accept the results of the *Source Testing* if:

(a) consultation and acceptance of the *Manager* did not take place,

(b) the *Source Testing Code* or the requirements of the *Manager*, either during the pre-test consultation or during witnessing of the *Source Testing*, were not followed, or

(c) the *Company* did not notify the Director, the *District Manager* and the *Manager* of the upcoming *Source Testing*, or

(d) the *Company* failed to provide the reports on the *Source Testing*.

(10) If the Director does not accept the results of the *Source Testing*, the Director may require the *Company* to repeat *Source Testing*.

CESSATION OF DISCHARGES

7. The *Company* shall implement the *Cessation of Discharges Protocol* when one or all of the following situations occur in the *Facility*:

(1) the concentration of nitrogen oxides in the discharge of the *Facility*, calculated in accordance with the third column of the table in Schedule "A" of this *Certificate*, exceeds the maximum limit set out in Schedule "A" of this *Certificate* for more than one (1) hour,

(2) the concentration of cadmium or lead in the discharge of the *Facility*, calculated in accordance with the third column of the table in Schedule "A" of this *Certificate*, exceeds the maximum limit set out in Schedule "A" of this *Certificate*,

(3) the concentration of mercury in the discharge of the *Facility*, if calculated in accordance with the stack test results specified in the third column of the table in Schedule "A" of this *Certificate*, exceeds the maximum limit set out in Schedule "A" of this *Certificate*, or if calculated in accordance with the results of the *CEM System* specified in the third column of the table in Schedule "A" of this *Certificate*, exceeds the maximum limit set out in Schedule "A" of this *Certificate* for more than one (1) hour,

(4) the concentration of hydrogen chloride, sulphur dioxide or organic matter in the discharge of the *Facility*, calculated in accordance with the third column of the table in Schedule "B" of this *Certificate*, exceeds the operational limit set out in Schedule "B" of this *Certificate* for more than one (1) hour,

(5) the concentration of dioxins or furans in the discharge of the *Facility*, calculated in accordance with the third column of the table in Schedule "B" of this *Certificate*, exceeds the operational limit set out in Schedule "B" of this *Certificate*, or

(6) the concentration of particulate matter in the discharge of the *Facility*, if calculated in accordance with the stack test results specified in the third column of the table in Schedule "B" of this *Certificate*, exceeds the operational limit set out in Schedule "B" of this *Certificate*, or if calculated in accordance with the results of the *CEM System* specified in the third column of the table in Schedule "B" of this *Certificate*, exceeds the operational limit set out in Schedule "B" of this *Certificate* for more than one (1) hour.

8. If the *Cessation of Discharges Protocol* is implemented, the *Company* shall, within twenty-four (24) hours after discharge from the *Facility* is resumed, initiate *Source Testing* for the contaminant the concentration of which was exceeded, when the emission of the contaminant is monitored by *Source Testing*.

REPORTING REQUIREMENTS

9. The *Company* shall prepare, beside the Source Testing reports required in condition 7(8) above, the following reports:

Monthly Engineer's Reports

(1) monthly progress reports, prepared in accordance with Condition 48 in the *Certificate of Approval (Waste)* and submitted to the *District Manager* within five (5) business days after the end of each calendar month starting from the month of the *Start-up Date*. The monthly report shall summarize the activities that have been undertaken in that month and the discharge from the *Facility*. The monthly report shall include the information required in Condition 48 in the *Certificate of Approval (Waste)* and the following:

(a) an executive summary,

(b) average and maximum daily quantity and the total quantity of *Municipal Waste* and *High Carbon Waste* received and processed by the *Facility* in that month,

(c) results of the *CEM System*, complete with a summary of the maximum concentration monitored and recorded for each contaminant in that month,

(d) date(s) and time(s) and the results if available of any *Source Testing* if conducted in that month, and

(e) details of planned maintenance or failure of equipment in the *Facility*.

Non-compliance Report

(2) non-compliance report, prepared and submitted to the *District Manager* immediately when the *Company* is aware of any non-compliance with *O. Reg. 254/06* or any condition or requirement of this *Certificate*.

Semi-annual Reports

(3) semi-annual reports, prepared and submitted to the *District Manager* in accordance with Condition 63 of the *Certificate of Approval (Waste)*, for each six-month period after the *Start-up Date* of the *Facility* and the equipment in the *Facility* has been operated within that period, on how the operation of the *Facility* complied with requirements of *O. Reg. 254/06* and the terms and conditions of this *Certificate* in that period.

Final Assessment Report

(4) a final assessment report, prepared in accordance with Condition 64 in the *Certificate of Approval (Waste)* and submitted to the *Director* and the *District Manager* not later than three (3) months after waste is last processed in the *Facility*, including all the information required in Condition 48 in the *Certificate of Approval (Waste)*.

<u>RECORD RETENTION</u>

10. The *Company* shall retain in the *Facility* or another location approved by the Director or *District manager*, for a period not less than five (5) years from the date of their creation, all records relating to monitoring, performance, equipment maintenance, waste quality and quantity processed in the *Facility*, including but not limited to the following:

(1) all original records produced by the recording devices associated with the *CEM System*,

(2) all records on the operation of the *Facility*, including the type and quantity of *Municipal Waste* and *High Carbon Waste* received and processed in the *Facility*,

(3) all results obtained during the *Source Testing*,

(4) all records related to inspection, repair and maintenance of the *Facility* and the *Equipment*,

(5) all records of any environmental complaints, handled and recorded in accordance with Condition 53 of the *Certificate of Approval (Waste)*.

The *Company* shall make all records required by this *Certificate* available to staff of the *Ministry* for review upon request.

NOTIFICATION OF MINISTRY

11. The *Company* shall notify the *District Manager* in writing, before the *Start-up Date* of the *Facility*, as to whether the construction of the *Facility* has been carried out in accordance with this *Certificate* to a point of substantial completion.

12. The *Company* shall notify the *District Manager*, in writing, of each environmental complaint in accordance with Condition 53 of the *Certificate of Approval (Waste)*.

Schedule "A"

Maximum Limits

Contaminant	Maximum Limit	Comments
Nitrogen oxides	110 ppmv	Calculated as the arithmetic average of 24 hours of data from a continuous emission monitoring system
Hydrogen chloride	18 ppmv	Calculated as the arithmetic average of 24 hours of data from a continuous emission monitoring system
Sulphur dioxide	21 ppmv	Calculated as the geometric average of 24 hours of data from a continuous emission monitoring system
Organic matter	100 ppmv	Calculated as a 10-minute average measured by a continuous emission monitoring system and expressed as equivalent methane
Particulate matter	17 mg/Rm3	Calculated as the arithmetic average of 3 stack tests conducted in accordance with standard methods or as measured by a continuous emission monitoring system
Mercury	20 ug/Rm3	Calculated as the arithmetic average of 3 stack tests conducted in accordance with standard methods or as measured by a continuous emission monitoring system
Cadmium	14 ug/Rm3	Calculated as the arithmetic average of 3 stack tests conducted in accordance with standard methods
Lead	142 ug/Rm3	Calculated as the arithmetic average of 3 stack tests conducted in accordance with standard methods
Dioxins and furans	80 pg/Rm3	Calculated as the arithmetic average of 3 stack tests conducted in accordance with standard methods, and expressed as toxicity equivalent to 2,3,7,8 tetrachlorodibenzo-p-dioxin (calculated using the international toxicity equivalence factors set out in Schedule "F" of this Certificate, corrected to 11 per cent oxygen and zero per cent moisture (dry).

Notes:
(1) ppmv means parts per million by volume.
(2) mg/Rm3 means milligrams per reference cubic metre.
(2) ug/Rm3 means micrograms per reference cubic metre.
(3) pg/Rm3 means picograms per reference cubic metre.

<u>Schedule "B"</u>

Operational Limits

Contaminant	Operational Limit	Comments
Hydrogen chloride	13 ppmv	Calculated as the arithmetic average of 24 hours of data from a continuous emission monitoring system
Sulphur dioxide	14 ppmv	Calculated as the geometric average of 24 hours of data from a continuous emission monitoring system
Organic matter	75 ppmv	Calculated as a 10-minute average measured by a continuous emission monitoring system and expressed as equivalent methane
Particulate matter	12 mg/Rm3	Calculated as the arithmetic average of 3 stack tests conducted in accordance with standard methods or as measured by a continuous emission monitoring system
Dioxins and furans	40 pg/Rm3	Calculated as the arithmetic average of 3 stack tests conducted in accordance with standard methods, and expressed as toxicity equivalent to 2,3,7,8 tetrachlorodibenzo-p-dioxin (calculated using the international toxicity equivalence factors set out in Schedule "F" of this Certificate, corrected to 11 per cent oxygen and zero per cent moisture (dry).

Notes:
(1) ppmv means parts per million by volume.
(2) mg/Rm3 means milligrams per reference cubic metre.
(2) ug/Rm3 means micrograms per reference cubic metre.
(3) pg/Rm3 means picograms per reference cubic metre.

Schedule "C"

SOURCE TESTING FOR POLYCYCLIC ORGANIC MATTER

Acenaphthylene
acenaphthene
anthracene
benzo(a)anthracene
benzo(b)fluoranthene
benzo(k)fluoranthene
benzo(a)fluorene
benzo(b)fluorene
benzo(ghi)perylene
benzo(a)pyrene
benzo(e)pyrene
2-chloronaphthalene
chrysene
coronene
dibenzo(a,c)anthracene
9,10 - dimethylanthracene
7,12 - dimethylbenzo(a)anthracene
fluoranthene
fluorene
indeno(1,2,3 - cd)pyrene
2 - methylanthracene
3 - methylcholanthrene
1 - methylnaphthalene
2 - methylnaphthalene
1 - methylphenanthrene
9 - methylphenanthrene
naphthalene
perylene
phenanthrene
picene
pyrene
tetralin
triphenylene
dibenzo(a,h)anthracene
dibenzo(a,e)pyrene
quinoline
biphenyl
o-terphenyl
m-terphenyl
p-terphenyl

Schedule "D"

SOURCE TESTING FOR VOLATILE ORGANIC MATTER

Acetaldehyde
acetone
acrolein
benzene
bromodichloromethane
bromoform
bromomethane
butadiene, 1,3 -
Butanone, 2 -
Carbon tetrachloride
chloroform
cumene
dibromochloromethane
dichlorodifluoromethane
dichloroethane, 1,2 -
Dichloroethene, trans - 1,2 -
Dichloroethene, 1,1 -
Dichloropropane, 1,2 -
Ethylbenzene
ethylene dibromide
formaldehyde
mesitylene
methylene chloride
styrene
tetrachloroethene
toluene
trichloroethane, 1,1,1 -
Trichloroethene
trichloroethylene, 1,1,2 -
Trichlorofluoromethane
trichlorotrifluoroethane
vinyl chloride
xylenes, m-, p- and o-

Schedule "E"

PARAMETER: Temperature

LOCATION:
The sample point for the continuous temperature monitoring and recording system shall be located at a location where the measurements are representative of the minimum temperature of the gases leaving the engine or flare stacks

PERFORMANCE:

The Continuous Temperature Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETER	SPECIFICATION
1. Type:	shielded "K" type thermocouple or equivalent
2. Accuracy:	± 1.5 percent of the minimum gas temperature

RECORDER:

The recorder must be capable of registering continuously the measurement of the monitor without a significant loss of accuracy and with a time resolution of 5 minutes or better.

RELIABILITY:

The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time, on a monthly basis, when the engines or the flare are in operation.

Schedule "E" (Cont'd)

PARAMETER: Oxygen

INSTALLATION:
The Continuous Oxygen Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of oxygen in the undiluted gases leaving the engine stacks or the flare stacks and shall meet the following installation specifications.

PARAMETERS	SPECIFICATION
1. Range (percentage):	0 - 20 or 0 - 25
2. Calibration Gas Ports:	close to the sample point

PERFORMANCE:
The Continuous Oxygen Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	SPECIFICATION
1. Span Value (percentage):	2 times the average normal concentration of the source
2. Relative Accuracy:	≤ 10 percent of the mean value of the reference method test data
3. Calibration Error:	0.25 percent O2
4. System Bias:	≤ 4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check:	all system components checked
6. Zero Calibration Drift (24-hour):	≤ 0.5 percent O2
7. Span Calibration Drift (24-hour):	≤ 0.5 percent O2
8. Response Time (90 percent response to a step change):	≤ 90 seconds
9. Operational Test Period:	≥ 168 hours without corrective maintenance

CALIBRATION:
Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER:

The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

RELIABILITY:

The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter.

Schedule "E" (Cont'd)

PARAMETER: Nitrogen Oxides

INSTALLATION:
The Continuous Nitrogen Oxides Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of nitrogen oxides in the gases leaving the engine stacks or the flare stacks and shall meet the following installation specifications.

PARAMETERS	SPECIFICATION
1. Analyzer Operating Range (ppm):	0 to 200
2. Calibration Gas Ports:	close to the sample point

PERFORMANCE:
The Continuous Nitrogen Oxides Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	SPECIFICATION
1. Span Value (nearest ppm equivalent):	2 times the average normal concentration of the source
2. Relative Accuracy:	$\leq$ 10 percent of the mean value of the reference method test data
3. Calibration Error:	$\leq$ 2 percent of actual concentration
4. System Bias:	$\leq$ 4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check:	all system components checked
6. Zero Calibration Drift (24-hour):	$\leq$ 2.5 percent of span value
7. Span Calibration Drift (24-hour):	$\leq$ 2.5 percent of span value
8. Response Time (90 percent response to a step change):	$\leq$ 200 seconds
9. Operational Test Period:	$\geq$ 168 hours without corrective maintenance

CALIBRATION:
Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter.

Schedule "E" (Cont'd)

PARAMETER: Carbon Monoxide

INSTALLATION:
The Continuous Carbon Monoxide Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of carbon monoxide in the undiluted gases leaving the engine stacks or the flare stacks and shall meet the following installation specifications.

PARAMETERS	SPECIFICATION
1. Range (percent):	0 to 0.2
2. Calibration Gas Ports:	close to the sample point

PERFORMANCE:
The Continuous Carbon Monoxide Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	SPECIFICATION
1. Span Value (nearest ppm equivalent):	2 times the average normal concentration of the source
2. Relative Accuracy:	$\leq$ 10 percent of the mean value of the reference method test data or ± 5 ppm whichever is greater
3. Calibration Error:	$\leq$ 2 percent of actual concentration
4. System Bias:	$\leq$ 4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check:	all system components checked
6. Zero Calibration Drift (24-hour):	$\leq$ 5 percent of span value
7. Span Calibration Drift (24-hour):	$\leq$ 5 percent of span value
8. Response Time (90 percent response to a step change):	$\leq$ 90 seconds
9. Operational Test Period:	$\geq$ 168 hours without corrective maintenance

CALIBRATION:
Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter.

PARAMETER: Hydrogen Chloride

INSTALLATION:
The Continuous Hydrogen Chloride Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of hydrogen chloride in the gases leaving the engine stacks or the flare stacks and shall meet the following installation specifications.

PARAMETERS	SPECIFICATION
1. Range (parts per million, ppm):	0 to 36
2. Calibration Gas Ports:	close to the sample point

PERFORMANCE:
The Continuous Hydrogen Chloride Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	SPECIFICATION
1. Span Value (nearest ppm equivalent):	2 times the average normal concentration of the source
2. Relative Accuracy:	≤ 20 percent of the mean value of the reference method test data or ± 5 ppm whichever is greater
3. Calibration Error:	≤ 2 percent of actual concentration
4. System Bias:	≤ 4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check:	all system components checked
6. Zero Calibration Drift (24-hour):	≤ 5 percent of span value
7. Span Calibration Drift (24-hour):	≤ 5 percent of span value
8. Response Time (90 percent response to a step change):	≤ 200 seconds
9. Operational Test Period:	≥ 168 hours without corrective maintenance

CALIBRATION:
The monitor shall be calibrated daily at the sample point, to ensure that it meets the drift limits specified above, during the periods of the operation of the engines or the flare. The results of all calibrations shall be recorded at the time of calibration.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 5 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter.

Schedule "E" (Cont'd)

PARAMETER: Sulphur Dioxide

INSTALLATION:
The Continuous Sulphur Dioxide Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of sulphur dioxide in the gases leaving the engine stacks or the flare stacks and shall meet the following installation specifications.

PARAMETERS	SPECIFICATION
1. Range (parts per million, ppm):	0 to 50
2. Calibration Gas Ports:	close to the sample point

PERFORMANCE:
The Continuous Sulphur Dioxide Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	SPECIFICATION
1. Span Value (nearest ppm equivalent):	2 times the average normal concentration of the source
2. Relative Accuracy:	≤ 10 percent of the mean value of the reference method test data
3. Calibration Error:	≤ 2 percent of actual concentration
4. System Bias:	≤ 4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check	all system components checked
6. Zero Calibration Drift (24-hour):	≤ 2.5 percent of span value
7. Span Calibration Drift (24-hour):	≤ 2.5 percent of span value
8. Response Time (90 percent response to a step change):	≤ 200 seconds
9. Operational Test Period:	≥ 168 hours without corrective maintenance

CALIBRATION:
Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter.

Schedule "E" (Cont'd)

PARAMETER: Total Hydrocarbons (Organic Matter)

INSTALLATION:
The Total Hydrocarbons Monitor shall be installed at an accessible location where the measurements are representative of the undiluted hydrocarbon concentrations of the gases leaving the engine stacks or the flare stacks and shall meet the following installation specifications.

PARAMETERS	**SPECIFICATION**
1. Detector Type:	Flame Ionization
2. Oven Temperature:	160 degrees Celsius minimum
3. Flame Temperature:	1800 degrees Celsius minimum at the corona of the hydrogen flame
4. Range (parts per million, ppm):	0 to 200
5. Calibration Gas:	propane in air or nitrogen
6. Calibration Gas Ports:	close to the sample point

PERFORMANCE:
The Continuous Total Hydrocarbons Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	**SPECIFICATION**
1. Span Value (nearest ppm equivalent):	2 times the average normal concentration of the source
2. Relative Accuracy:	≤ 10 percent of the mean value of the reference method test data or ± 5 ppm whichever is greater
3. System Bias:	≤ 4 percent of the mean value of the reference method test data
4. Noise:	≤ 1 percent of span value on most sensitive range
5. Repeatability:	≤ 1 percent of span value
6. Linearity (response with propane in air):	≤ 3 percent of span value over all ranges
7. Calibration Error:	≤ 2 percent of actual concentration

8. Procedure for Zero and Span Calibration Check: all system components checked on all ranges
9. Zero Calibration Drift (24-hours): $\leq$ 2.5 percent of span value on all ranges
10. Span Calibration Drift (24-hours): $\leq$ 2.5 percent of span value
11. Response Time (90 percent response to a step change): $\leq$ 60 seconds
12. Operational Test Period: $\geq$ 168 hours without corrective maintenance

CALIBRATION:
Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

SCHEDULE "F"

INTERNATIONAL TOXICITY EQUIVALENCE FACTORS

Dioxin/Furan Isomers of Concern	International Toxicity Equivalence Factors (I-TEF's)
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	0.5
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	0.01
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	0.001
2,3,7,8-Tetrachlorodibenzofuran	0.1
2,3,4,7,8-Pentachlorodibenzofuran	0.5
1,2,3,7,8-Pentachlorodibenzofuran	0.05
1,2,3,4,7,8-Hexachlorodibenzofuran	0.1
1,2,3,6,7,8-Hexachlorodibenzofuran	0.1
1,2,3,7,8,9-Hexachlorodibenzofuran	0.1
2,3,4,6,7,8-Hexachlorodibenzofuran	0.1
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.01
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.01
1,2,3,4,6,7,8,9-Octachlorodibenzofuran	0.001

The reasons for the imposition of these terms and conditions are as follows:

1. Condition 1 is included to assist the *Ministry* with the review of the *Company*'s compliance with *O. Reg. 254/06*.

2. Conditions 2 and 3 are included to outline the minimum performance requirements considered necessary to prevent an adverse effect resulting from the operation of the *Activated Carbon Filters* and the *Facility*.

3. Conditions 4 and 5 are included to emphasize that the *Facility* and the *Equipment* must be operated and maintained according to a procedure that will result in compliance with the *Act*, the regulations and this *Certificate*.

4. Condition 6 is included to require the *Company* to gather accurate information so that the environmental impact and subsequent compliance with the *Act*, the regulations and this *Certificate* can be verified.

5. Conditions 7 and 8 are included to ensure that the *Facility* is operated in accordance with the requirements of *O. Reg. 254/06* and that the *Facility* must be operated according to a procedure to prevent an adverse effect resulting from the operation of the *Facility*.

6. Conditions 9 and 10 are included to require the *Company* to prepare records to provide information to the *Ministry* so that the environmental impact and subsequent compliance with the *Act*, the regulations and this *Certificate* can be verified.

7. Conditions 11 and 12 are included to require the *Company* to notify staff of the *Ministry* so as to assist the *Ministry* with the review of the *Facility*'s compliance with the *Act*, the regulations and this *Certificate*.

In accordance with Section 139 of the Environmental Protection Act, R.S.O. 1990, Chapter E-19, as amended, you may by written notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 142 of the Environmental Protection Act, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;

6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the works are located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary*****		The Director
Environmental Review Tribunal		Section 9, *Environmental Protection Act*
2300 Yonge St., Suite 1700		Ministry of the Environment
P.O. Box 2382	AND	2 St. Clair Avenue West, Floor 12A
Toronto, Ontario		Toronto, Ontario
M4P 1E4		M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

The above noted works are approved under Section 9 of the Environmental Protection Act.

DATED AT TORONTO this 1st day of December, 2006

Victor Low, P.Eng.
Director
Section 9, *Environmental Protection Act*

RW/
c: District Manager, MOE Ottawa District Office
Richard Urbanski, SENES Consultants Limited

APPENDIX E-3

Clean Harbors Hazardous Waste Incinerator and Landfill, Sarnia, ON

Under the Environmental Protection Act and the regulations and subject to the limitations thereof, this Provisional Certificate of Approval is issued to:

Laidlaw Environmental Services (Sarnia) Ltd.
265 North Front Street, Suite 502
Sarnia, Ontario
N7T 7X1

for the use and operation of a landfill site with a total fill area of approximately 56 hectares which includes the pre-1985 fill area, the current operating 14.3 hectare fill area and the expansion fill area of 13.1 hectares and a landfill pretreatment system all within a total site area of 121.4 hectares.

all in accordance with the following plans and specifications:

As per Schedule "A"

Located: Lot 9, and Part of Lot 8, Concession 10
Township of Moore
County of Lambton

which includes the use of the site only for the processing and disposal *of the following categories of waste (Note: Use of the site or additional categories of wastes requires a new application and amendments to the Provisional Certificate of Approval)* as specified in conditions 3 and 4.

and subject to the following conditions:

1. For the purpose of this Provisional Certificate of Approval:

   (a) "Director" means any Ministry employee appointed by the Minister pursuant to Section 5 of the Environmental Protection Act, R.S.O. 1990;
   (b) "Company" means only Laidlaw Environmental Services (Sarnia) Ltd.;
   (c) "District Manager" means the District Manager of the Ministry of Environment and Energy for the Sarnia District Office;
   (d) "MOEE" means the Ontario Ministry of Environment and Energy;
   (e) "Regional Director" means the Director of the Southwest Region of the Ontario Ministry of Environment and Energy; and
   (f) "District Office" means the Ontario Ministry of Environment and Energy Sarnia District Office;
   (g) "CL/AC" means Community Liaison/Advisory Committee.
   (h) "Property" means the lands located as described above.

2. Except as otherwise provided by these conditions, the landfill site and the landfill pretreatment system shall be operated in accordance with the documents listed in Schedule "A".

3. Acceptable Wastes for Pretreatment System

Subject to the qualification provided in condition 5, the following Ministry of Environment and Energy waste classes may be accepted for processing and solidification at the landfill pretreatment system; 111-114 inclusive, 121, 122, 123, 131-135 inclusive, 141-150 inclusive, 211, 212, 213, 221, 222, 231, 232, 233, 241, 242, 251-254 inclusive, 261-270 inclusive, 281, 282, 311 and 321.

4. Acceptable Wastes for Landfill

Subject to the qualification provided in condition 5, the following categories of waste may be accepted for disposal at the landfill site:

(a) non-hazardous solid industrial waste;
(b) solidified wastes from the landfill pretreatment system;
(c) the residues or contaminated materials from the clean-up of a spill that have a slump of less than 150 mm using the Test Method for the Determination of Liquid Waste ("slump test") as set out in Regulation 347; and
(d) solid wastes having a slump of less than 150 mm (using the slump test), of the following Ministry of Environment and Energy waste classes; 111-114 inclusive, 121-123 inclusive, 131-135 inclusive,, 141-150 inclusive, 211-213 inclusive, 221, 222, 231-233 inclusive, 241, 242, 251-254 inclusive, 261-270 inclusive, 281, 282, 311 and 321.

5. Waste Restrictions

Except with the prior approval of the District Manager, the following wastes as defined in Regulation 347 under the Environmental Protection Act shall not be accepted for processing and solidification at the landfill pretreatment system or for disposal at the landfill site:

(a) ignitable wastes
(b) radioactive wastes
(c) pesticide wastes
(d) reactive waste
(e) waste streams containing greater than 2% by weight of:

  i) halogenated and non-halogenated organic chemicals which in their pure state:

  - are non-solid, and
  - exhibit an equilibrium vapour pressure in excess of 10 mm of mercury at 25°C, and
  - have a molecular weight of less than 300 atomic mass units.

ii) aromatic compounds which contain one or more nitrogen atoms and

a) have an equilibrium vapour pressure in their pure state greater than 10 mm of mercury at 25°C and have a molecular weight less than 300 atomic mass units and are non-solid at 25°C.

or

b) are listed dangerous goods in the Transportation of Dangerous Goods Act and have a primary or subsidiary designation of Class 1 (Explosives) of Class 4 (Flammable Solids).

iii) constituents contained in Schedule 2, Parts A and B of Ontario Regulation 347 which in their pure state:

- are non-solid, and
- exhibit an equilibrium vapour pressure in excess of 10 mm of mercury at 25°C, and
- have a molecular weight of less than 300 atomic mass units.

(f) The Company shall obtain the written concurrence of the District Manager prior to the pretreatment or disposal of any of the restricted wastes where the Company are proposing a change to the primary or secondary waste characterization as identified on a subject manifest by the generator. The analysis conducted in support of a proposed change to the waste class characterization shall be done consistent with the requirements under Regulation 347.

6. Analysis of Solidified Product and Neutralized Liquid Waste

For the landfill pretreatment system, each batch of neutralized liquid wastes and the solidified product are to be sampled and analyzed to ensure that the following specifications for moisture content and stability are met:

i) the solidified waste product will have a moisture content of less than 35% weight/weight (w/w);

ii) the solidified waste product will exhibit a slump (as measured by the standard test method defined in O. Reg. 347) of less than 50% as initially prepared and will exhibit a resistance to penetration of not less than 15 psi on 24 hours curing.

7. Changes to the Final Design and Operations (D&O) Report

(a) The CL/AC shall receive copies of any documents relating to the approval, design and operations of the landfill site prior to the submission of any application for changes to the operation of the site or revised documentation that are subject to the Director's approval.

(b) The Company shall submit the final revised D&O Report to the Director, for approval, within 90 days of the date of this approval.

8. Daily Records

Daily records shall be kept at the landfill site and the landfill pretreatment system of quantities and types of waste received including origin of the waste, the results of any analysis performed and the location in the cell where the wastes are deposited.

9. Monitoring Programs

(a) The Site Monitoring Programs shall be conducted as described in the following Sections of the Design and Operations Report (D&O Report):

i) Groundwater, sections 6.4.1, 6.4.2 and 6.4.3
ii) Cap integrity, section 6.4.4
iii) Surface water, section 6.5
iv) Air Quality, section 6.6.1
v) Biomonitoring, section 6.6.2

(b) Soil cores from the cap shall be sampled and analyzed as described in Section 6.4.4 of the D&O Report.

(c) The Company shall carry out the monitoring program as approved and with any amendments as required or approved, in writing, from time to time by the Regional Director.

(d) The results of all analyses performed pursuant to the program shall be submitted to the Regional Director within one month of each analysis being completed.

(e) If the results of the monitoring program demonstrate that contaminants are moving away from the base of the waste cells and through the soils at a rate and concentration greater than those predicted by the diffusion model, then the operations of the landfill site and any additional mitigative measures are to be reviewed by the Approvals Director.

(f) In addition to (a) i) above, the Company shall submit an enhanced groundwater monitoring program to the Regional Director, for approval, within 90 days after the date of issuance of this certificate.

10. Surface Water

(a) The Company shall take all reasonable steps to ensure that liquid at the base of the active working face does not exceed a depth of 0.3 metres.

(b) All liquid collected from the base of the active working face shall be incinerated or disposed of at a hazardous waste facility approved for the disposal of that type of waste.

(c) All surface water collected from Area I and, as delineated Figure 4-8 of the D&O Report, shall be incinerated or disposed at a facility approved for the disposal of that type of waste.

(d) Surface water collected from Areas II and III as delineated in Figure 4-8 of the D&O Report shall be treated by trickling filter, sand filter and carbon polishing and may only be discharged to the Telfer Road ditch if the following criteria are met:

i) total suspended solids shall not exceed 15 mg/L
ii) solvent extractables shall not exceed 15 mg/L
iii) total phenols shall not exceed 0.02 mg/L
iv) pH shall be in the range of 5.5 to 9.5
v) the water does not exhibit acute toxicity as measured by a standard test using a species like Rainbow Trout; or another equivalent test as may be approved by the Regional Director.
vi) no discharge may interfere with drainage in the ditch or be discharged at such a rate as to increase the turbidity in the ditch or cause erosion, and;
vii) all discharge must comply with the Objectives for Control of Industrial Discharges in Ontario and the approval No. 4-012-86-006 issued under the Ontario Water Resources Act.

11. Abandoned Wells

During the progress of landfilling, the company shall locate, remove and seal all wells in the area of the trench, including observation wells, old water wells and oil and gas test wells. A well decommissioning protocol shall be included in the revised D&O Report required by condition 7 (b).

12. Surficial Sand and Gravel

Any surficial sand and gravel deposits in the area between the cell and the outside of the perimeter berm shall be removed prior to berm construction to prevent underdrain conditions from occurring.

13. Access Roads

All access roads to the landfill site shall be maintained in accordance with procedures described in Section 4.8.3 of the D&O Report to minimize dust generation at the site.

14. Landfill Cap

The 5.1 metre cap over the waste shall be constructed as described in Section 4.4 of the D&O Report in order to minimize hydraulic conductivity to the degree that molecular diffusion is the dominant factor controlling the rate of contaminant migration.

Quality control of cap construction shall be monitored as described in Section 6.3 of the D&O Report.

15. Annual Report

The Company shall submit annual reports to the MOEE Regional Director on or before November 30th of each year. Such reports shall cover the year ending the previous August 31st and shall include the following information as required for the landfill site and landfill pretreatment system:

(a) the results of an interpretive analysis of all monitoring programs as defined in conditions 9 and 10;
(b) a summary of waste received for landfilling and pretreatment at the site including quantities, types and origin;
(c) a list of all rejected vehicles together with reasons for any rejection;
(d) a report on the progress of landfilling including total capacity used and the remaining site life, berm development, the extent and location of any gravel or sand lenses excavated and the location of any old wells discovered and plugged; and
(e) a summary and discussion of past analytical data based on previous annual reports showing trends in data and potential future concerns.

16. Insurance and Securities for the Landfill Site

(a) Insurance

A policy of environmental liability insurance providing coverage of at least $5,000,000 per occurrence with an annual aggregate of at least $10,000,000 shall be kept in force at all times including after closure of the site, until the Approvals Director is satisfied that it is no longer necessary to do so. The policy shall cover sudden and non-sudden emissions of contaminants from the site and shall cover bodily injury and property damage. If such insurance becomes unavailable, the Director shall be notified immediately upon notice from the insurance institution and extra securities shall be deposited with the Director in order to maintain third party coverage.

(b) Immediate Response fund

The Company shall provide the sum of $25,000 to the Township of Moore to be held in trust by the Township for emergency water supply, if necessary. The Company shall enter into an agreement with the Township respecting the administration of the trust fund including provisions for replenishment, payments and an administration fee.

(c) Closure and Post-Closure Security

Prior to the disposal of any waste at the landfill site, the Company shall provide to the Approvals Director financial security of type and form satisfactory to the Director in the amount of $750,000 to ensure the completion of closure and post-closure activities at the site.

(d) Contingencies and Remedial Action Security

Prior to the disposal of any waste at the landfill site, the Company shall provide to the approvals Director financial security of a type and form satisfactory to the Director in the amount of $1,500,000 to guarantee that appropriate contingency and remedial action measures will be implemented if and when required.

(e) The Company shall submit reports to the Approvals Director every five years updating the cost estimates on which the financial securities referred to in (c) and (d) above were based, taking into consideration any changes proposed in the operation and closure of the site and cost increases due to inflation.

(f) The amount of the financial securities referred to in (c) and (d) above shall be adjusted by the Approvals Director in accordance with the reports submitted, if accepted by the Director as satisfactory, and the Company shall provide any additional or replacement financial security as required by the Director.

(g) If, at any time, notice is received that an institution which has issued either of the financial security instruments referred to above, proposes to revoke or not renew the security instruments at a time when replacement security has not been furnished, the Company will immediately inform the Director and the security may be drawn upon and the amount placed in the Consolidated Revenue Fund of the Province of Ontario.

17. Prohibition/Registration on Title

(a) Pursuant to Section 197 of the Environmental Protection Act, neither the Owner nor any person having an interest in the Property shall deal with the Property in any way without first giving a copy of this Certificate to each person acquiring an interest in the Property as a result of the dealing.

(b) The Owner shall:

i) Within 60 days of the date of this Certificate, submit to the Director for the Director's signature two copies of a completed Certificate of Prohibition containing a registrable description of the Property, in accordance with Form 1 of O. Reg. 14/92.

ii) Within 10 calendar days of receiving the Certificates of Prohibition signed by the Director, register the Certificate of Prohibition in the appropriate Land Registry Office on title to the Property and submit to the Director immediately following registration the duplicate registered copy.

18. Replacement of Previous Provisional Certificate of Approval

This Provisional Certificate of Approval revokes all previously issued Provisional Certificates of Approval issued under Part V of the Environmental Protection Act for the landfill site, Provisional Certificate of Approval No. A 031806 and the landfill pretreatment system Provisional Certificate of Approval No. A 031822. The approval given herein, including the terms and conditions set out, replaces all previously issued approvals and related terms and conditions under Part V of the Act for the aforementioned landfill site and pretreatment system.

19. Odour Control and Monitoring

A program shall be maintained to minimize and control odours, which may have an impact off-property, as described in Section 3.2.6.3 of the D&O Report.

20. Complaint Response Procedure

The Facility shall maintain the ability to receive and respond to complaints concerning off-property impacts on a 24 hour basis. Complaints impacts shall be recorded upon receipt and referred to the Shift Supervisor. The complaint shall be investigated by the Shift Supervisor as soon as possible after receipt and a direct response made to the complainant within 12 hours.

If the complaint resulted from an off-property impact caused by the facility, the Shift Supervisor shall take immediate steps to rectify the situation, including, if necessary, restricting Facility Operations until the impact ceases.

The Company shall forthwith notify the Ministry of all complaints that are received at the Facility.

21. Closure and Post Closure

Closure and Post Closure shall mean the phases outlined in Section 7 of the D&O Report. The Closure and Post Closure procedures, monitoring and maintenance shall be carried out as described in this Section.

22. Mitigation of Nuisance Effects

Programs shall be maintained to minimize and mitigate off-property impacts due to noise, sediment, dust, lighting and odour as described in Section 4.8 of the D&O Report.

SCHEDULE "A"

This Schedule "A" forms part of Provisional Certificate of Approval No. A 031806

1. Application for Approval of a Waste Disposal Site, dated May 8, 1996.

2. EA Document 3 - Site Assessment Report, Volumes 1 and 2, dated April 1996.

3. EA Document 4 - Design and Operations Report, dated April 1996.

4. Environmental Assessment Landfill Continuation, Technical Reports Volumes 1 and 2, dated April 1996.

5. EA Document 5 - Response to Environmental Assessment Review, dated January 1997.

6. Letter from the Company's, Mr. Eric Hunter, Director Special Projects, to the MOEE, dated February 28, 1997, correcting typographical errors in the application in item 1.

7. Copy, dated May 8, 1997, of an Order in Council made on May 7, 1997 regarding the approval, pursuant to the Environmental Assessment Act, to proceed with an undertaking subject to conditions.

The reasons for the imposition of these conditions are as follows:

1. The reason for condition 1 is to simplify the wording in the subsequent conditions and to define the specific meaning of the terms used in this Certificate.

2. The reason for condition 17 is that it was added pursuant to subsection 197(1) of the Environmental Protection Act, to provide that any persons having an interest in the Property are aware that the land has been approved and used for the purposes of waste disposal.

3. The reason for condition 18 is to ensure that the site is operated in accordance with this Provisional Certificate of Approval and not with previously issued certificates.

4. The reason for conditions 2 through 22 is that they ensure compliance with the Act and regulations or they are required, on probable grounds, to address potential nuisances, achieve the public interest, or avoid hazards to the health or safety of any person. Also, these conditions are in large measure the result of discussions between experts on behalf of the Company and the public, and Ministry staff. Due to those discussions, the precise rationale for each particular condition is well known to the parties involved.

The establishment, use and operation of this site without the above conditions may create a nuisance or result in a hazard to the health and safety of any person.

In accordance with Section 139 of the Environmental Protection Act, R.S.O. 1990 c. E-19, you may by written notice served upon me and the Environmental Appeal Board within 15 days after receipt of this Notice, require a hearing by the Board. Section 142 of the Environmental Protection Act, as amended provides that the Notice requiring a hearing shall state:

1. *The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;*
2. *The grounds on which you intend to rely at the hearing in relation to each portion appealed.*

In addition to these legal requirements, the Notice should also include:

3. *The name of the appellant;*
4. *The address of the appellant;*
5. *The Certificate of Approval number;*
6. *The date of the Certificate of Approval;*
7. *The name of the Director;*
8. *The municipality within which the waste disposal site is located;*

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary,
Environmental Appeal Board,
2300 Yonge St., 12th Floor,
P. O. Box 2382,
Toronto, Ontario
M4P 1E4

AND

The Director,
Section 39, Environmental Protection Act,
Ministry of the Environment and Energy,
250 Davisville Avenue, 3rd Floor,
Toronto, Ontario
M4S 1H2

DATED AT TORONTO this 5th *day of* September, 1997.

A. Dominski, P.Eng.
Director,
Section 39,
Environmental Protection Act

APPENDIX E-4

2132656 Ontario Inc. (Remasco) Solid Non-Hazardous Waste Incinerator, Kingsville, ON

CONTENT COPY OF ORIGINAL

Date Required:	2008/03/30

Ontario

Ministry of the Environment | Ministère de l'Environnement

PROVISIONAL CERTIFICATE OF APPROVAL
WASTE DISPOSAL SITE
NUMBER 2887-7AAQTX
Issue Date: May 2, 2008

2132656 Ontario Inc.
1746 Seacliff Dr E
Kingsville, Ontario
N9Y 2M6

Site Location: Southshore Greenhouse Test Program
1746 Seacliff Dr E
Kingsville Town, County of Essex

You have applied in accordance with Section 27 of the Environmental Protection Act for approval of:

a waste disposal site

to be used for the incineration of the following types of waste:

solid non-hazardous waste, limited as per the Conditions of this Certificate

Note: Use of the site for any other type of waste is not approved under this Certificate, and requires obtaining a separate approval amending this Certificate.

For the purpose of this Provisional Certificate of Approval and the terms and conditions specified below, the following definitions apply:

1. "*Certificate*" means this entire *provisional certificate of approval* document, issued in accordance with section 39 of the *EPA*, and includes any schedules to it, the application and the supporting documentation listed in Schedule "A";

"Company" means 2132656 Ontario Inc., including its successors and assigns;

"*Director*" means any *Ministry* employee appointed in writing by the *Minister* pursuant to section 5 of the *EPA* as a Director for the purposes of Part V of the *EPA*;

"*District Manager*" means the *District Manager* of the local district office of the *Ministry* in which the *Site* is geographically located;

"*EPA*" means *Environmental Protection Act*, R.S.O. 1990, c. E. 19, as amended;

"Manager" means the Manager, Technology Standards Section, Standards Development Branch of the Ministry, or any other person who represents and carries out the duties of the Manager, as those duties relate to the conditions of this Certificate;

"Manual" means a document or a set of documents that provide written instructions to staff of the Company;

"Ministry" means the Ontario Ministry of the Environment;

"*Operator* " means any person, other than the *Owner's* employees, authorized by the *Owner* as having the charge, management or control of any aspect of the site, and includes its successors or assigns;

"*Owner*" means any person that is responsible for the establishment or operation of the site being approved by this

Certificate, and includes 2132656 Ontario Inc., its successors and assigns;

"*OWRA*" means the *Ontario Water Resources Act*, R.S.O. 1990, c. O-40, as amended from time to time;

"*PA*" means the *Pesticides Act*, R.S.O. 1990, c. P-11, as amend from time to time;

"Point of Impingement" means any point in the natural environment. The point of impingement for the purposes of verifying compliance with the Act shall be chosen as the point located outside the company's property boundaries at which the highest concentration is expected to occur, when that concentration is calculated in accordance with Regulation 419/05 written under the Act, or any other method accepted by the Director;

"Pre-test Information" means the information outlined in Section 1 of the Source Testing Code;

"*Provincial Officer*" means any person designated in writing by the Minister as a provincial officer pursuant to section 5 of the *OWRA* or section 5 of the *EPA* or section 17 of *PA*.

"*Regional Director*" means the Regional Director of the local Regional Office of the *Ministry* in which the *Site* is located;

"*Reg. 347*" means Regulation 347, R.R.O. 1990, made under the *EPA*, as amended from time to time;

"*Reg. 419/05*" means Regulation 419/05, made under the *EPA*, as amended from time to time;

"*Site*" means the entire waste disposal site, located at 1746 Seacliff Dr E, Kingsville Town, County of Essex, approved by this *Certificate*;

"Source Testing" means sampling and testing to measure emissions resulting from operating the Combustors at a level of maximum production within the approved operating range of the Combustors;

"Source Testing Code" means the Source Testing Code, Version 2, Report No. ALB-66-80, dated November 1980, prepared by the Ministry, as amended;

"Test Contaminants" means those contaminants set out in Schedule "C" attached to this Certificate of Approval;

"Trained personnel" means knowledgeable in the following through instruction and/or practice:

a. relevant waste management legislation, regulations and guidelines;
b. major environmental concerns pertaining to the waste to be handled;
c. occupational health and safety concerns pertaining to the processes and wastes to be handled;
d. management procedures including the use and operation of equipment for the processes and wastes to be handled;
e. emergency response procedures;
f. specific written procedures for the control of nuisance conditions;
g. specific written procedures for refusal of unacceptable waste loads;
h. the requirements of this *Certificate*.

"Combustor" means the combustor described in Item 1 of Schedule "A".

You are hereby notified that this approval is issued to you subject to the terms and conditions outlined below:

TERMS AND CONDITIONS

GENERAL

Compliance

2. The *Owner* and *Operator* shall ensure compliance with all the conditions of this *Certificate* and shall ensure that any person authorized to carry out work on or operate any aspect of the *Site* is notified of this *Certificate* and the conditions

herein and shall take all reasonable measures to ensure any such person complies with the same.

3. Any person authorized to carry out work on or operate any aspect of the *Site* shall comply with the conditions of this *Certificate*.

Build, etc. in Accordance

4. Except as otherwise provided by this *Certificate*, the *Site* shall be designed, developed, built, operated and maintained in accordance with the application for this *Certificate*, dated October 5, 2007, and the supporting documentation listed in Schedule "A".

Interpretation

5. Where there is a conflict between a provision of any document, including the application, referred to in this *Certificate*, and the conditions of this *Certificate,* the conditions in this *Certificate* shall take precedence.

6. Where there is a conflict between the application and a provision in any documents listed in Schedule "A", the application shall take precedence, unless it is clear that the purpose of the document was to amend the application and that the *Ministry* approved the amendment.

7. Where there is a conflict between any two documents listed in Schedule "A", other than the application, the document bearing the most recent date shall take precedence.

8. The requirements of this *Certificate* are severable. If any requirement of this *Certificate*, or the application of any requirement of this *Certificate* to any circumstance, is held invalid or unenforceable, the application of such requirement to other circumstances and the remainder of this certificate shall not be affected thereby.

Other Legal Obligations

9. The issuance of, and compliance with the conditions of, this *Certificate* does not:

a. relieve any person of any obligation to comply with any provision of any applicable statute, regulation or other legal requirement; or

b. limit in any way the authority of the *Ministry* to require certain steps be taken or to require the *Owner* and *Operator* to furnish any further information related to compliance with this *Certificate*.

Adverse Effects

10. The *Owner* and *Operator* shall take steps to minimize and ameliorate any adverse effect on the natural environment or impairment of water quality resulting from the *Site*, including such accelerated or additional monitoring as may be necessary to determine the nature and extent of the effect or impairment.

11. Despite an *Owner*, *Operator* or any other person fulfilling any obligations imposed by this certificate the person remains responsible for any contravention of any other condition of this *Certificate* or any applicable statute, regulation, or other legal requirement resulting from any act or omission that caused the adverse effect to the natural environment or impairment of water quality.

Change of Owner

12. The *Owner* shall notify the *Director* in writing, and forward a copy of the notification to the *District Manager,* within 30 days of the occurrence of any changes:

a. the ownership of the *Site*
b. the *Operator* of the *Site;*
c. the address of the *Owner* or *Operator*;
d. the partners, where the *Owner* is or at any time becomes a partnership and a copy of the most recent declaration filed

under the *Business Names Act,* R.S.O. 1990, c. B-17 shall be included in the notification; or
e. the name of the corporation where the *Owner* is or at any time becomes a corporation, other than a municipal corporation, and a copy of the most current information filed under the *Corporations Information Act*, R.S.O. 1990, c. C-39 shall be included in the notification.

13. No portion of this *Site* shall be transferred or encumbered prior to or after closing of the *Site* unless the *Director* is notified in advance and sufficient financial assurance is deposited with the *Ministry* to ensure that these conditions will be carried out. In the event of any change in *Ownership* of the *Site*, other than change to a successor municipality, the *Owner* shall notify the successor of and provide the successor with a copy of this *Certificate*, and the *Owner* shall provide a copy of the notification to the *District Manager* and the *Director.*

Financial Assurance

14. The *Owner* shall submit to the *Director*, Financial Assurance as defined in Section 131 of the *EPA*, in the amount of $6,538. This Financial Assurance shall be in a form and amount acceptable to the *Director* and shall provide sufficient funds to pay for compliance with and performance of any action specified in this *Certificate*, including the site clean-up, monitoring and disposal of all quantities of waste on-site, closure and post-closure care of the *Site* and contingency plans for the *Site***.**

15. A written report reviewing the Financial Assurance required by the conditions in this *Certificate* shall be submitted to the *Director* and the *District Manager* by March 31, 2009, and shall be updated and submitted annually on the anniversary date and shall include updates of the discount, interest and inflation rates associated with the requirements for Financial Assurance in this *Certificate* including justifications and sources of the proposed rates.

16. If any Financial Assurance is scheduled to expire or notice is received, indicating Financial Assurance will not be renewed, and satisfactory methods have not been made to replace the Financial Assurance at least 60 days before the Financial Assurance terminates, the Financial Assurance shall forthwith be replaced by cash.

Inspections

17. No person shall hinder or obstruct a *Provincial Officer* in the performance of their duties, including any and all inspections authorized by the *OWRA*, the *EPA* or the *PA* of any place to which this *Certificate* relates, and without limiting the foregoing to:

a. enter upon the premises where the *Site* is located, or the location where the records required by the conditions of this *Certificate* are kept;
b. have access to, inspect, and copy any records required by the conditions of this *Certificate*;
c. inspect the practices, procedures, or operations required by the terms conditions of this *Certificate*; and
d. sample and monitor for the purposes of assessing compliance with the conditions of this *Certificate* or the *EPA*, the *OWRA* or the *PA.*

Information and Record Retention

18. Any information requested, by the *Ministry*, concerning the *Site* and its operation under this *Certificate*, including but not limited to any records required to be kept by this *Certificate* shall be provided to the *Ministry,* upon request**.** Records shall be retained for 5 years except for as otherwise authorized in writing by the *Director.*

19. The receipt of any information by the *Ministry* or the failure of the *Ministry* to prosecute any person or to require any person to take any action, under this *Certificate* or under any statute, regulation or other legal requirement, in relation to the information, shall not be construed as:

a. an approval, waiver, or justification by the *Ministry* of any act or omission of any person that contravenes any term or condition of this *Certificate* or any statute, regulation or other legal requirement; or

b. acceptance by the *Ministry* of the information’s completeness or accuracy.

<u>OPERATIONS</u>

Operations

20. (a) The *Site* shall be operated and maintained, and the management and disposal of all waste shall be carried out, in accordance with the *EPA*, *Regulation 347* and the conditions of this *Certificate.* At no time shall the discharge of a contaminant that causes or is likely to cause an adverse effect be permitted.

(b) Not withstanding the Conditions of this *Certificate,* no waste shall be incinerated pursuant to this *Certificate*after 90 days from the date of issuance.

Hours of Operation

21. Waste shall only be accepted at the *Site* from 6:00am to 9:00pm.

22. With the prior written approval of the *District Manager*, the time periods may be extended to accommodate seasonal or unusual quantities of waste.

Service Area

23. Only waste that is generated in the Province of Ontario shall be accepted at the *Site.*

Waste Types

24. Only solid non-hazardous waste, limited to municipal solid waste pellets from the York Region Material Recovery and Transfer Facility, located at 100 Garfield Wright Blvd, Town of East Gwillimbury, Ontario, shall be accepted at the *Site*.

Waste Limits

25. (a) No more than 50 tonnes or waste per day shall be accepted at the *Site*.

(b) No more than 5 tonnes of waste per day shall be incinerated at the *Site*.

26. No more than 50 tonnes of waste shall be stored or be present on-site at any time. If for any reason waste cannot be transferred from the site, the *Site* shall cease accepting waste.

Signage

27. A sign shall be posted and maintained at the main entrance/exit to the site in a manner that is clear and legible, and shall include the following information:

a. the name of the *Site* and *Owner*;
b. this *Certificate* number;
c. the name of the *Operator*;
d. the normal hours of operation;
e. the allowable and prohibited waste types;
f. a telephone number to which complaints may be directed;
g. a twenty-four (24) hour emergency telephone number (if different from above); and
h. a warning against dumping outside the *Site*.

Waste Inspection

28. All waste shall be inspected by *Trained personnel* prior to being accepted at the *Site* to ensure that the waste is of a type approved for acceptance under this *Certificate*.

29. In the event that any waste load is refused, a record shall be made in the daily log book of the reason the waste was refused and the origin of the waste, if known.

Incoming / Outgoing Waste

30. All activities related to the unloading, loading, transfer and storage of waste shall be conducted indoors at all times, with the exception of temporary overflow waste storage at the northeast corner of the main building.

31. All incoming and outgoing wastes shall be inspected by *Trained personnel* prior to being received, processed, incinerated, transferred and/or shipped to ensure wastes are being managed and disposed of in accordance with the *EPA* and *Reg. 347.*

Labelling

32. All waste storage containers as the *Site* shall have a label or sign clearly identifying the contents.

Vermin, etc.

34. The *Site* shall be operated and maintained such that vermin, vectors, dust, litter, odour, noise and traffic do not create a nuisance.

Design and Operations Report

35. The Design and Operations Report (Item 1 in Schedule "A") shall be retained at the *Site*, kept up to date through periodic revisions, and be available for inspection by *Ministry* staff. Changes to the Design and Operations Report shall be submitted to the *Director* for approval.

Training Plan

36. A training plan shall be developed and maintained for all employees that operate the *Site*. Only *Trained personnel* may operate the *Site* or carry out any activity required under this *Certificate*.

37. The *Owner* shall ensure that *Trained personnel* are available at all times during the hours of operation of this *Site*. *Trained personnel* shall supervise all transfer or processing of waste material at the *Site***.**

Site Security

38. The *Site* shall be operated and maintained in a secure manner, such that unauthorized persons cannot enter the *Site*.

Site Inspection

39. An inspection of the entire *Site* and all equipment on the *Site* shall be conducted each day the *Site* is in operation to ensure that: the *Site* is secure; that the operation of the *Site* is not causing any nuisances; that the operation of the *Site* is not causing any adverse effects on the environment; and that the *Site* is being operated in compliance with this *Certificate*. Any deficiencies discovered as a result of the inspection shall be remedied immediately, including temporarily ceasing operations at the *Site* if needed.

40. A record of the inspections, including the following information, shall be kept in the daily log book:

a. the name and signature of person that conducted the inspection;
b. the date and time of the inspection;
c. a list of any deficiencies discovered;
d. any recommendations for remedial action; and
e. the date, time and description of actions taken.

Complaint Response

41. If at any time, the *Owner* receives complaints regarding the operation of the *Site*, the *Owner* shall respond to these complaints according to the following procedure:

a. The *Owner* shall record and number each complaint, either electronically or in a separate log book, along with the following information:

i. the nature of the complaint,
ii. if the complaint is odour or nuisance related, the weather conditions and wind direction at the time of the complaint;
iii. the name, address and telephone number of the complainant (if provided); and
iv. the time and date of the complaint;

b. The *Owner*, upon notification of the complaint, shall initiate appropriate steps to determine all possible causes of the complaint, proceed to take the necessary actions to eliminate the cause of the complaint and forward a formal reply to the complainant; and

c. The *Owner* shall complete and retain on-site a report written within one (1) week of the complaint date, listing the actions taken to resolve the complaint and any recommendations for remedial measures, and managerial or operational changes to reasonably avoid the recurrence of similar incidents.

Emergency Response Plan

42. Copies of the Emergency Response Plan shall be provided to the *District Manager*, the local Municipality and the Fire Department.

43. The Emergency Response Plan shall be kept up to date, and a copy shall be retained in a central location on the *Site* accessible to all staff at all times. Changes to the Emergency Response Plan shall be submitted to the *Director* for approval.

44. The equipment, materials and personnel requirements outlined in the Emergency Response Plan shall be immediately available on the *Site* at all times. The equipment shall be kept in a good state of repair and in a fully operational condition.

45. All staff that operate the *Site* shall be fully trained in the use of the contingency and Emergency Response Plan, and in the procedures to be employed in the event of an emergency.

46. The *Owner* shall immediately take all measures necessary to contain and clean up any spill or leak which may result from the operation of this *Site* and immediately implement the emergency response plan if required.

Closure Plan

47. A Closure Plan shall be submitted to the *Director* for approval, with a copy to the *District Manager,* no later than six (6) months before the planned closure date of the *Site*. The Closure Plan shall include, at a minimum, a description of the work that will be done to facilitate closure of the *Site* and a schedule for completion of that work.

48. The *Site* shall be closed in accordance with the approved Closure Plan.

49. Within 10 days after closure of the *Site*, the *Owner* shall notify the *Director*, in writing, that the *Site* is closed and that the approved Closure Plan has been implemented.

<u>AIR EMISSIONS</u>

Operation and Maintenance

50. The Company shall ensure that the Combustor is properly operated and maintained at all times. The Company shall:

(1) prepare, no later than one (1) month after the date of this Certificate, and update, as necessary, a Manual outlining the operating procedures and a maintenance program for the Combustor, including:

> (a) routine operating and maintenance procedures in accordance with good engineering practices and as recommended by the Combustor suppliers;
> (b) emergency procedures;

(c) procedures for any record keeping activities relating to operation and maintenance of the Combustor; and
(d) all appropriate measures to minimize noise and odorous emissions from all potential sources;

(2) implement the recommendations of the Manual.

Performance Requirements

51. The Company shall ensure that the concentration of the following contaminants in the undiluted gas emitted from the Combustor shall not exceed the limits set out in the following table, normalized to 11 percent oxygen at reference temperature of 25 degrees Celsius and a reference pressure of 101.3 kilopascals:

Contaminant	Emission Limit
particulate matter	17 mg/Rm3
cadmium	14 ug/Rm3
lead	142 ug/Rm3
mercury	20 ug/Rm3
dioxins and furans	80 pg/Rm3
hydrochloric acid	18 ppmv (27 mg/Rm3) or an HCl removal efficiency of not less than 95%
sulphur dioxide	21 ppmv (56 mg/Rm3)
nitrogen oxides	110 ppmv

52. The Company shall ensure that the operation of the Combustor complies with the following limits:

(1) the temperature in the combustion chamber, as recorded by the continuous temperature monitoring system, shall be at least 1000 degrees Celsius at all times, and the residence time, of the products of combustion and the combustion air, in the combustion chamber shall be not less than one (1) second.

(2) the concentration of organic matter expressed as equivalent methane, in the undiluted flue gas shall not exceed 100 parts per million by volume, on a dry basis, based on an average of ten measurements taken at approximately one minute intervals.

(3) the concentration of oxygen in the undiluted flue gas, as recorded by the continuous oxygen monitoring system, shall not be less than 6 percent by volume on a dry basis.

(4) the average opacity of the flue gas, as recorded by the continuous opacity monitoring system, shall not exceed 20 percent based on a continuous six minute average.

Monitoring

53. The Company shall monitor the emissions and operation of the Combustor in accordance with the following requirements:

Source Testing

(1) The Company shall perform Source Testing in accordance with the procedure in the attached Schedule “B”, to determine the rate of emission of the Test Contaminants from the Combustor.

Continuous Monitoring

(2) The Company shall install, conduct and maintain a program to continuously monitor the temperature, opacity, carbon monoxide and oxygen in the flue gas of the Combustor. The continuous monitoring system shall be equipped with continuous recording devices and shall comply with the requirements outlined in the attached Schedule "D".

Record Retention

54. The Company shall retain, for a minimum of two (2) years from the date of their creation, all records and information related to or resulting from the monitoring and recording activities required by this Certificate, and make these records available for review by staff of the Ministry upon request. The Company shall retain, as a minimum:

(1) all records on the maintenance, repair and inspection of the Combustor;

(2) all records produced by the continuous monitoring systems;

(3) all calibration and maintenance records including any log books: and

(4) all records on the environmental complaints; including:

(a) a description, time and date of each incident to which the complaint relates;
(b) wind direction at the time of the incident to which the complaint relates; and
(c) a description of the measures taken to address the cause of the incident to which the complaint relates and to prevent a similar occurrence in the future.

RECORDS AND REPORTING

Daily Log Book

55. A daily log shall be maintained, either electronically or in written format, and shall include the following information as a minimum:

a. the date;
b. types (class and primary characteristic), quantities and source of waste received;
c. quantity of unprocessed, processed and residual waste on the *Site*;
d. quantities and destination of each type of waste shipped from the *Site*;
e. a record of daily inspections required by this *Certificate;*
f. a record of any spills or process upsets at the site, the nature of the spill or process upset and the action taken for the clean up or correction of the spill, the time and date of the spill or process upset, and for spills, the time that the *Ministry* and other persons were notified of the spill in fulfilment of the reporting requirements in the *EPA* .
g. a record of any waste refusals which shall include; amounts, reasons for refusal and actions taken; and
h. the signature of the *Trained Personnel* conducting the inspection and completing the report.

Annual Report

56. On March 31, 2009, and on an annual basis thereafter, a written report shall be prepared for the previous calendar year ("*Annual Report*"). The Annual Report shall be submitted to the *District Manager* by March 31 of each year. The report shall include, at a minimum, the following information:

a. a detailed monthly summary of the type and quantity of all incoming and outgoing wastes and the destination of all outgoing wastes;

b. any environmental and operational problems, that could negatively impact the environment, encountered during the operation of the *Site* and during the facility inspections and any mitigative actions taken;

c. any changes to the Emergency Response Plan, the Design and Operations Report and the Closure Plan that have been approved by the Director since the last *Annual Report.*

d. any recommendations to minimize environmental impacts from the operation of the *Site* and to improve *Site* operations and monitoring programs in this regard.

This Schedule "A" forms a part of this Certificate:

1. Application for a Provisional Certificate of Approval for a Waste Disposal Site dated October 5, 2007, signed by Jim Gallant, VP Operations Engineering, including the attached report entitled "Certificate of Approval (Waste Disposal Site) Application for Solid Fuel Boiler" dated October 4, 2007, and all supporting documentation.

Schedule "B"

This Schedule "B" forms a part of this Certificate:

Procedure for Source Testing

1. The Company shall submit, no later than one (1) month after the commencement of operation of the Combustor, to the Manager a test protocol, including the Pre-Test Information for the Source Testing required by the Source Testing Code.

2. The Company shall finalize the test protocol in consultation with the Manager.

3. The Company shall not commence the Source Testing until the Manager has accepted the test protocol.

4. The Company shall complete the Source Testing not later than three (3) months after the Manager has accepted the test protocol.

5. The Company shall notify the District Manager and the Manager in writing of the location, date and time of any impending Source Testing required by this Certificate, at least fifteen (15) days prior to the Source Testing.

6. The Company shall submit a report on the Source Testing to the District Manager and the Manager no later than two (2) months after completing the Source Testing. The report shall be in the format described in the Source Testing Code, and shall also include, but not be limited to:

(1) an executive summary;

(2) records of operating conditions, and all records produced by the continuous monitoring systems; and

(3) the results of dispersion calculations in accordance with Regulation 419/05 indicating the maximum concentrations of the Test Contaminants at the Point of Impingement;

7. The Director may not accept the results of the Source Testing if:

(1) the Source Testing Code or the requirements of the Manager were not followed;

(2) the Company did not notify the District Manager and the Manager of the Source Testing; or

(3) the Company failed to provide a complete report on the Source Testing.

8. If the Director does not accept the results of the Source Testing, the Director may require re-testing.

Schedule "C"

This Schedule "C" forms a part of this Certificate:

Test Contaminants

Carbon monoxide
Total suspended particulate matter
Formaldehyde
Acrolein
Phenol
Methanol
Propionaldehyde
Acetaldehyde
Nitrogen oxides
Hydrogen Chloride

Vinyl Chloride

List of Polycyclic Organic Matter	List of Dioxin/Furan Isomers
Acenaphthylene Acenaphthene Anthracene Benzo(a)anthracene Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(a)fluorene Benzo(b)fluorene Benzo(ghi)perylene Benzo(a)pyrene Benzo(e)pyrene 2-Chloronaphthalene Chrysene Coronene Dibenzo(a,c)anthracene 9,10-Dimethylanthracene 7,12-Dimethylbenzo(a)anthracene Fluoranthene Fluorene Indeno(1,2,3-cd)pyrene 2-Methylanthracene 3-Methylcholanthrene 1-Methylnaphthalene 2-Methylnaphthalene 1-Methylphenanthrene 9-Methylphenanthrene Naphthalene Perylene Phenanthrene Picene Pyrene Tetralin Triphenylene	2,3,7,8-Tetrachlorodibenzo-p-dioxin 1,2,3,7,8-Pentachlorodibenzo-p-dioxin 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin 1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin 2,3,7,8-Tetrachlorodibenzofuran 2,3,4,7,8-Pentachlorodibenzofuran 1,2,3,7,8-Pentachlorodibenzofuran 1,2,3,4,7,8-Hexachlorodibenzofuran 1,2,3,6,7,8-Hexachlorodibenzofuran 1,2,3,7,8,9-Hexachlorodibenzofuran 2,3,4,6,7,8-Hexachlorodibenzofuran 1,2,3,4,6,7,8-Heptachlorodibenzofuran 1,2,3,4,7,8,9-Heptachlorodibenzofuran 1,2,3,4,6,7,8,9-Octachlorodibenzofuran

Schedule "C" (cont'd)

List of Metals
Antimony Arsenic Barium Beryllium Cadmium Chromium Cobalt Copper Lead Mercury Molybdenum Nickel Selenium Silver Thallium Vanadium Zinc

Schedule "C" (cont'd)

International toxicity equivalency factors (I-TEFs) are applied to 17 dioxin and furan isomers of concern to convert them into 2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin) toxicity equivalents. The conversion involves multiplying the concentration of the isomer by the appropriate I-TEF to yield the TEQ for this isomer. Summing the individual TEQ values for each of the isomers of concern provides the total toxicity equivalent level for the sample mixture.

A table listing the 17 isomers of concern and their I-TEFs can be found in the MOE publication titled: Environmental Information - Dioxin & Furans; PIBS 681b, revised 09/91 or in the example provided below.

Example:

Dioxin / Furan Isomers of Concern	**International Toxicity Equivalency Factors (I-TEFs)**	**Concentration pg/m3 (Analytically measured)**	**Toxicity Equivalent (TEQ) pg TEQ/m3**
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1.0	0.01	0.01
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	0.5	0.011	0.0055
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	0.1	0.006	0.0006
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	0.1	0.01	0.001
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	0.1	0.019	0.0019
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	0.01	0.15	0.0015
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	0.001	-	-
2,3,7,8-Tetrachlorodibenzofuran	0.1	0.11	0.011
2,3,4,7,8-Pentachlorodibenzofuran	0.5	0.033	0.0165
1,2,3,7,8-Pentachlorodibenzofuran	0.05	0.024	0.0012
1,2,3,4,7,8-Hexachlorodibenzofuran	0.1	0.03	0.003
1,2,3,6,7,8-Hexachlorodibenzofuran	0.1	0.016	0.0016
1,2,3,7,8,9-Hexachlorodibenzofuran	0.1	0.016	0.0016
2,3,4,7,8,9-Hexachlorodibenzofuran	0.1	0.007	0.0007
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.01	0.047	0.0047
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.01	0.008	0.00008
1,2,3,4,6,7,8,9-Octachlorodibenzofuran	0.001	-	-
Total Toxicity Equivalent			**0.06088 ***

* Sum of toxicity equivalents of individual isomers

The I-TEF scheme is intended to be used with isomer specific analytical results. In cases where results are reported by congener group only, staff at MOE's Standards Development Branch should be contacted for appropriate procedures to convert non-isomer specific data to TEQs.

Schedule "D"

This Schedule "D" forms a part of this Certificate:

PARAMETER: Temperature

LOCATION: The sample point for the Continuous Temperature Monitor shall be located at the exit of the combustion chamber of the Combustor at a point representing a minimum combustion gas residence time of one (1) second.

PERFORMANCE: The Continuous Temperature Monitor shall meet the following minimum performance specifications for the following parameters.

	PARAMETERS	SPECIFICATION
1	Type	shielded "K" type thermocouple, or equivalent
2	Accuracy	1.5 percent of the minimum gas temperature

DATA RECORDER: The data recorder must be capable of registering continuously the measurement of the monitor without a significant loss of accuracy and with a time resolution of 1 minute or better.

RELIABILITY: The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 95 percent of the time for each Calendar quarter.

Schedule "D" (cont'd)

PARAMETER: Oxygen

INSTALLATION: The Continuous Oxygen Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of oxygen in the undiluted gases leaving the Combustor and shall meet the following installation specifications:

	PARAMETERS	SPECIFICATION
1	Range (percentage)	0 - 20 or 0 - 25
2	Calibration Gas Ports	close to the sample point

PERFORMANCE: The Continuous Oxygen Monitor shall meet the following minimum performance specifications for the following parameters:

	PARAMETERS	SPECIFICATION
3	Span Value (percentage)	2 times the average normal concentration of the source
4	Relative Accuracy	$\leq$ 10 percent of the mean value of the reference method test data
5	Calibration error	0.25 percent O_2
6	System Bias	$\leq$ 4 percent of the mean value of the reference method test data
7	Procedure for Zero and Span Calibration Check	all system components checked
8	Zero Calibration Drift (24-hour)	$\leq$ 0.5 percent O_2
9	Span Calibration Drift (24-hour)	$\leq$ 0.5 percent O_2
10	Response time (90 percent response to a step change)	$\leq$ 90 seconds
11	Operational Test Period	168 hours without corrective maintenance

CALIBRATION: Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER: The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

RELIABILITY: The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter.

Schedule "D" (cont'd)

PARAMETER: Carbon Monoxide

INSTALLATION: The Continuous Carbon Monoxide Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of carbon monoxide in the undiluted gases leaving the Combustor and shall meet the following installation specifications:

	PARAMETERS	SPECIFICATION
1	Range (parts per million, ppm)	0 to ≥ 200
2	Calibration Gas Ports	close to the sample point

PERFORMANCE: The Continuous Carbon Monoxide Monitor shall meet the following minimum performance specifications for the following parameters:

	PARAMETERS	SPECIFICATION
3	Span Value (nearest ppm equivalent)	2 times the average normal concentration of the source
4	Relative Accuracy	≤ 10 percent of the mean value of the reference method test data or ± 5 ppm, whichever is greater
5	Calibration error	≤ 2 percent of the actual concentration
6	System Bias	≤ 4 percent of the mean value of the reference method test data
7	Procedure for Zero and Span Calibration Check	all system components checked
8	Zero Calibration Drift (24-hour)	≤ 5 percent of span value
9	Span Calibration Drift (24-hour)	≤ 5 percent of span value
10	Response time (90 percent response to a step change)	≤ 90 seconds
11	Operational Test Period	168 hours without corrective maintenance

CALIBRATION: Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER: The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

RELIABILITY: The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter.

Schedule "D" (cont'd)

PARAMETER: Opacity

INSTALLATION: The Continuous Opacity Monitor shall be installed at an accessible location where the measurements are representative of the actual opacity of the gases leaving the Combustor and shall meet the following design and installation specifications:

	PARAMETERS	SPECIFICATION
1	Wavelength at Peak Spectral Response (nanometres, nm)	500 - 600
2	Wavelength at Mean Spectral Response (nm)	500 - 600
3	Detector Angle of View	≤ 5 degrees
4	Angle of Projection	≤ 5 degrees
5	Range (percent of opacity)	0 - 100

PERFORMANCE: The Continuous Opacity Monitor shall meet the following minimum performance specifications for the following parameters:

	PARAMETERS	SPECIFICATION
6	Span Value (percent opacity)	2 times the average normal opacity of the source
7	Calibration error	≤ 3 percent opacity
8	Attenuator Calibration	≤ 2 percent opacity
9	Response time (95 percent response to a step change)	≤ 10 seconds
10	Schedule for Zero and Span Calibration Checks	daily minimum
11	Procedure for Zero and Span Calibration Checks	all system components checked
12	Zero Calibration Drift (24-hour)	≤ 2 percent opacity
13	Span Calibration Drift (24-hour)	≤ 2 percent opacity
14	Conditioning Test Period	≥ 168 hours without corrective maintenance
15	Operational Test Period	≥ 168 hours without corrective maintenance

CALIBRATION: The monitor shall be calibrated, to ensure that it meets the drift limits specified above, during the periods of the operation of the Combustor. The results of all calibrations shall be recorded at the time of calibration.

DATA RECORDER: The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 30 seconds or better.

RELIABILITY: The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter.

The reasons for the imposition of these terms and conditions are as follows:

1. The reason for Condition 1 is to simplify the wording of the subsequent conditions and define the specific meaning of terms as used in this Provisional Certificate of Approval.

2. The reason for Conditions 2, 3, 5, 6, 7, 8, 9, 10, 11, 18, and 19 is to clarify the legal rights and responsibilities of the Owner and Operator.

3. The reason for Condition 4 is to ensure that the Site is operated in accordance with the application and supporting documentation submitted by the Company, and not in a manner which the Director has not been asked to consider.

4. The reasons for Condition 12 is to ensure that the Site is operated under the corporate name which appears on the application form submitted for this approval and to ensure that the Director is informed of any changes.

5. The reasons for Condition 13 are to restrict potential transfer or encumbrance of the Site without the approval of the Director and to ensure that any transfer of encumbrance can be made only on the basis that it will not endanger compliance with this Certificate of Approval.

6. The reason for Condition 14, 15 and 16 is to ensure that sufficient funds are available to the Ministry to clean up the Site

in the event that the Company is unable or unwilling to do so.

7. The reason for Condition 17 is to ensure that appropriate Ministry staff have ready access to the Site for inspection of facilities, equipment, practices and operations required by the conditions in this Certificate of Approval. This condition is supplementary to the powers of entry afforded a Provincial Officer pursuant to the EPA and OWRA.

8. The reason for Conditions 20, 30, 31 and 34 is to ensure that the Site is operated in a manner which does not result in a nuisance or a hazard to the health and safety of the environment or people.

9. The reasons for Conditions 21 and 22 are to specify the hours of operation for the Site and a mechanism for amendment of the hours of operation, as required.

10. The reasons for Conditions 23, 24, 25 and 26 are to specify the approved service area from which waste may be accepted at the Site, the types of waste that may be accepted at the Site, the amounts of waste that may be stored at the Site and the maximum rate at which the Site may receive waste based on the Company's application and supporting documentation.

11. The reason for Condition 27 is to ensure that users of the Site are fully aware of important information and restrictions related to Site operations and access under this Certificate of Approval.

12. The reasons for Conditions 28 and 29 are to ensure that all incoming wastes are inspected to ensure compliance with this *Certificate*, and to ensure that a record is made of any waste load refusal.

13. The reason for Condition 32 is to ensure all waste on the Site are properly labelled.

14. The reason for Condition 36 and 37 is to ensure that the Site is operated by properly Trained staff in a manner which does not result in a hazard or nuisance to the natural environment or any person.

15. The reasons for Condition 38 are to ensure the controlled access and integrity of the Site by preventing unauthorized access when the Site is closed and no site attendant is on duty.

16. The reasons for Conditions 39 and 40 are to ensure that routine Site inspections are completed, and that detailed records of Site inspections are recorded and maintained for inspection and information purposes.

17. The reason for Condition 41 is to ensure that any complaints regarding Site operations at the Site are responded to in a timely manner.

18. The reasons for Conditions 42, 43, 44, 45 and 46 are to ensure that an Emergency Response Plan is developed and maintained at the Site and that staff are properly trained in the operation of the equipment used at the Site and emergency response procedures.

19. The reasons for Condition 47, 48 and 49 are to ensure that the Site is closed in accordance with Ministry standards and to protect the health and safety of the public and the environment.

20. The reason for Conditions 50, 53 and 54 is ensure that the Combustors are maintained and operated according to a procedure that will result in compliance with the Act, the regulations and this Certificate, and to ensure monitoring information is gathered accurately so that the environmental impact and subsequent compliance with the Act, the Regulations and this Certificate can be verified.

21. The reason for Conditions 51 and 52 is to outline the minimum performance requirements considered necessary to prevent an adverse effect resulting from the operation of the Equipment and the Combustors.

21. The reasons for Condition 55 are to provide for the proper assessment of effectiveness and efficiency of site design and operation, their effect or relationship to any nuisance or environmental impacts, and the occurrence of any public complaints or concerns. Record keeping is necessary to determine compliance with this Certificate of Approval, the EPA and its regulations.

22. The reasons for Condition 56 are to ensure that regular review of site development, operations and monitoring data is documented and any possible improvements to site design, operations or monitoring programs are identified. An annual report is an important tool used in reviewing site activities and for determining the effectiveness of site design.

In accordance with Section 139 of the Environmental Protection Act, R.S.O. 1990, Chapter E-19, as amended, you may by written Notice served upon me, the Environmental Review Tribunal and in accordance with Section 47 of the Environmental Bill of Rights, S.O. 1993, Chapter 28, the Environmental Commissioner, within 15 days after receipt of this Notice, require a hearing by the Tribunal. The Environmental Commissioner will place notice of your appeal on the Environmental Registry. Section 142 of the Environmental Protection Act, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the works are located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary*	AND	The Environmental Commissioner	AND	The Director
Environmental Review Tribunal		1075 Bay Street, 6th Floor		Section 39, *Environmental Protection Act*
2300 Yonge St., Suite 1700		Suite 605		Ministry ofthe Environment
P.O. Box 2382		Toronto, Ontario		2 St. Clair Avenue West, Floor 12A
Toronto, Ontario		M5S 2B1		Toronto, Ontario
M4P 1E4				M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

This instrument is subject to Section 38 of the Environmental Bill of Rights, that allows residents of Ontario to seek leave to appeal the decision on this instrument. Residents of Ontario may seek leave to appeal within 15 days from the date this decision is placed on the Environmental Registry. By accessing the Environmental Registry at www.ene.gov.on.ca, you can determine when the leave to appeal period ends.

The above noted waste disposal site is approved under Section 39 of the Environmental Protection Act.

DATED AT TORONTO this 2nd day of May, 2008

Tesfaye Gebrezghi, P.Eng.
Director
Section 39, *Environmental Protection Act*

AN/
c: District Manager, MOE Windsor
Albert John Chandler, A. J. Chandler & Associates Ltd.

APPENDIX E-5

Enquest Power Corporation Pilot Gasification Plant, Sault Ste. Marie, ON

CONTENT COPY OF ORIGINAL

Ministry of the Environment | Ministère de l'Environnement

Ontario

CERTIFICATE OF APPROVAL
AIR
NUMBER 0335-6VYML6
Issue Date: December 4, 2006

Enquest Power Corporation
1397 Station Street, Fonthill
Fonthill, Ontario
L0S 1E0

Site Location: Sault Ste. Marie Landfill Site
402 Fifth Line East
Sault Ste. Marie City, District of Algoma

You have applied in accordance with Section 9 of the Environmental Protection Act for approval of:

a pilot plant for experiments involving gasification of coal and thermal degradation of woodwaste, sewage sludge, paper waste and domestic waste, consisting of:

1. Receiving room for materials receiving and preprocessing including a manual waste sorting area together with a shredder for domestic waste and a water proof storage bin for recyclables, having a capacity of approximately 220 litres or 0.5 metric tonne, measuring one metre by one metre by 1.5 metres, and a storage bin for incidental subject wastes, having a capacity of approximately 220 litres or 0.5 tonne, measuring one metre by one metre by 1.5 metres, with incoming waste, sorted incoming waste and shredded waste placed in piles on the receiving room floor with no more than two piles at a time, and with the receiving room being maintained under negative pressure by directing the room air for use as combustion air;

2. one skid steer for material transfers within the building;

3. spent filter storage room measuring 1.2 metres by 1.2 metres by 2.4 metres for Spent Activated Carbon Filters and Spent HEPA Filters as shown on the Layout Drawing dated November 24, 2006 with reference to Filter Room;

4. eight leak-proof storage bins for kiln residue, each having a capacity of 0.75 metric tonne or 0.62 cubic metre, stacked two-high in a row of four containers, located in the main process room as shown on the Layout Drawing dated November 24, 2006 with reference to Residue Containers;

5. two leak-proof barrels, each having a capacity of 225 litres, located within a dyked area measuring approximately 1.5 metres by 3 metres complete with a concrete barrier of at least 10 centimetres in height, with the dyked area treated with an impervious coating, located in the main process room as shown on the Layout Drawing dated November 24, 2006 with reference to Spill Barrels, to allow short term storage in case of a scrubber liquor spill;

6. Ecolo system, including eight treatment locations, to treat odor emissions from all areas within the building where the pilot project is operated;

7. emergency power supply system, including a natural gas fired generator rated at 37 kilowatts with a maximum gas firing rate of 1.41 cubic metres per minute, located outdoors and discharging into the atmosphere via a stack extending 6.4 metres above grade;

8. nitrogen purge system to leak test the Kiln, to purge the system at the end of each test run, to maintain optimum Kiln operating conditions or as required due to operational issues;

9. electric steam generator used to supply steam to be mixed with the kiln feed in the feed hopper as needed;

10. three feed hoppers as shown on the Layout Drawing dated November 24, 2006 and a feed conveyor;

11. one rotary kiln, having an external diameter of 2.1 metres and an external length of 9.1 metres, complete with one combustion air blower rated at 0.1 cubic metre per second, six natural gas fired burners with a total maximum heat input of 1, 370, 000 kilojoules per hour and eight thermocouples, discharging the products of combustion into the atmosphere via a stack extending one metre above the roof and 6.38 metres above grade, to process woodwaste, paper waste, sewage sludge, coal or domestic waste, each material type fed through a hopper and auger separately and not mixed with each other, at a maximum rate of three tonnes per day, with the gaseous products directed via a cooling jacket having a length of 1.2 metres into a gas treatment system or, in case of emergency, into the enclosed flare;

12. one electrically heated rotary kiln, having an external diameter of 2.1 metres and an external length of 9.1 metres, to process coal, woodwaste, paper waste, sewage sludge or domestic waste, each material type fed through a hopper and auger separately and not mixed, at a maximum rate of three tonnes per day, discharging the gaseous products via a cooling jacket, having a length of 1.2 metres, into a gas treatment system or or, in case of emergency, into the enclosed flare;

13. gas treatment system consisting of the following:

a. two inlet quench coolers, one for each of the two Kilns, referred to as Water Jackets on the Layout Drawing, dated November 24, 2006 and Process Flow Diagram, dated October 7, 2006 each measuring 1.2 metres by 1.2 metres by 1.8 metres to cool the gases leaving the Kiln before the gases enter the Scrubber, complete with a chevron mist eliminator at the top of each of the two coolers;

b. one venturi scrubber having a height of 2.21 metres and an internal diameter of 0.30 metre in the primary flow section with a variable width throat section, providing a minimum differential pressure drop across the venturi throat of 8.72 kilopascals, complete with sodium hydroxide scrubbing liquor at 25 percent by weight concentration with a recirculation rate ranging from 250 to 350 litres per minute and spill containment pit measuring 2.44 metres by 3.66 metres by 1.22 metres, equipped with a sump pump for removing scrubber liquor spills for disposal by an approved waste disposal company;

c. two chevron mist eliminators, one at the top of the spray column in the venturi scrubber and the other in the gas-liquid separator;

d. one heat exchanger to cool the scrubbing liquor to a temperature of 50^{O}C;

e. one high efficiency particulate air (HEPA) filter complete with a pleated prefilter made of non-woven cotton and polyester blend and a main fiberglass separator style filter measuring 0.61 metre by 0.61 metre with a depth of 0.30 metre, providing an actual filtering face velocity of 0.18 metre per second;

f. three sulphur impregnated activated carbon filters, each measuring 0.61 metre by 0.61 metre with a depth of 0.30 metre and each with a carbon weight of 14.5 kilograms;

14. one induced draft fan rated at a minimum of 0.24 cubic metre per second;

15. one enclosed flare, serving as an afterburner, to incinerate the gases exiting the gas treatment system, complete with a natural gas fired burner rated at a maximum of 350,000 kilojoules per hour, discharging into the atmosphere at a volumetric flow rate of 0.35 actual cubic metre per second at a temperature of approximately 1000^{O}C via an exit having an internal diameter of 0.61 metre at a height of 10.92 metres above grade;

all in accordance with the plans and specifications as listed in Schedule “A” which is attached to, and forms part of this Certificate of Approval (Air), except as specified in the Conditions contained herein.

For the purpose of this Certificate of Approval and the terms and conditions specified below, the following definitions apply:

“Activated Carbon Filter” means the activated carbon filter approved by this Certificate to control emissions generated by the gasification or thermal degradation of Kiln Feed in the Kiln ;

"Certificate" means this entire certificate of approval document, issued in accordance with section 9 of the EPA and includes all the Schedules;

"Commencement Date of Operation" means the date when coal, woodwaste, paper waste, sewage sludge or Domestic Waste is first received at the Pilot Plant, whichever occurs first;

"Continuous Monitoring and Control System" means the methods and equipment used to monitor, control and record various parameters as required by conditions of this Certificate;

“City” means the Corporation of the City of Sault Ste. Marie;

"Dioxins and Furans" means polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans as also referenced in Schedule 2 of this Certificate;

"Director" means any person appointed in writing by the Minister of the Environment pursuant to section 5 of the EPA as Director for the purposes of Section 9 of the EPA;

“District Manager” means the District Manager of the local district office of the Ministry responsible for the geographical location of the Site;

“Domestic Waste” means waste that is Municipal Waste but is limited to waste that has characteristics similar to that collected at curbside from households but from which Incidental Subject Waste and Recyclables have been removed;

"Emergency Power Supply" means the electrical power generated by a natural gas fired generator for the purpose of maintaining essential services during interruption of normal power supply, including safe shut down of the Kiln in the event of a prolonged failure of the normal power supply;

"EPA" means Environmental Protection Act, R.S.O 1990, c. E.19, as amended from time to time;

"Equipment" means the Shredder, the nitrogen purge system, the steam generator, the Kilns, the quench coolers, the Scrubber, mist eliminators, heat exchanger, the HEPA Filter, the Activated Carbon Filters, the Enclosed Flare, the Continuous Monitoring and Control System components, the Ecolo odor treatment system and all auxiliary equipment necessary for proper operation of the Pilot Plant;

“Enclosed Flare” means the fume incinerator used to oxidize gaseous compounds generated as a result of gasification of coal and thermal degradation of woodwaste, sewage sludge, paper waste or Domestic Waste;

"Facility" means the entire operation located at the Site;

“Gas Residence Time” means the time that the emissions, generated by the gasification or thermal degradation of Kiln Feed in the Kiln, will be exposed to the required combustion temperature within the Enclosed Flare;

"Gas Treatment System" means the Scrubber, the HEPA Filter and the three Activated Carbon Filters, approved by this Certificate, used to control emissions generated by the gasification or thermal degradation of Kiln Feed in the Kiln;

"Hazardous Waste" has the same meaning as in Regulation 347;

“HEPA Filter” means the high efficiency particulate air filter approved by this Certificate;

"Incidental Subject Waste" means Hazardous Waste and Liquid Industrial Waste that are received at the Landfill commingled with municipal waste and that are separated from the waste before this waste is approved as Kiln Feed;

“Independent and Knowledgeable Professional Engineer” means a Professional Engineer who is not an employee of the Owner, who has not been involved in the design of the Pilot Plant or preparation of documentation required with any application for approval of the Pilot Plant but who is knowledgeable about the EPA, Regulation 347 and Regulation 419/05, Ministry guidelines affecting thermal degradation facilities and this Certificate and the Waste Certificate as well as experienced with regard to assessing compliance with environmental legislation and requirements of certificates of approval issued under the EPA;

“Kiln” means the natural gas fired, indirectly heated or the electrically heated rotary kiln, approved by the Waste Certificate and this Certificate;

“Kiln Feed” means coal and solid non-hazardous waste limited to woodwaste, sewage sludge, paper waste and Domestic Waste as approved to be fed into the Kiln;

“Kiln Residue” means the solids remaining in the Kiln after the Kiln Feed has been gasified or thermally degraded in the Kiln;

“Landfill” means the landfill site owned by the City, located at 402 Fifth Line East in Sault Ste. Marie;

"Liquid Industrial Waste" has the same meaning as in Regulation 347;

"Manager" means Manager, Technology Standards Section, Standards Development Branch of the Ministry, or successor, including any other person who represents and carries out the duties of the Manager, or successor, as those duties relate to the conditions of this Certificate;

"Ministry" means the Ontario Ministry of the Environment, or successor;

“Municipal Waste” has the same meaning as in Regulation 347;

"Ontario Source Testing Code" means the Ministry publication entitled “Source Testing Code, Version 2”, dated November 1980, as amended from time to time;

"Operator" means any person, other than the Owner's employees, authorized by the Owner as having the charge, management or control of any aspect of the site;

"Owner" means any person that is responsible for the establishment or operation of the site being approved by this Certificate, and includes Enquest Power Corporation, its successors and assigns;

"OWRA" means Ontario Water Resources Act, R.S.O. 1990, c. O-40, as amended from time to time;

"PA" means the Pesticides Act, R.S.O. 1990, c. P-11, as amended from time to time;

“Paper Waste” means solids from paper manufacturing, excluding wastes that are not predominantly paper fiber and that are rejected from pulping operations;

“Pilot Plant” means the building, complete with the Emergency Power Supply, used for the storage and handling of and experimentation with coal and wastes, including all the equipment approved by this Certificate;

"Point of Impingement" has the same meaning as in Regulation 419/05;

“Process Room” means the room housing the Kilns, as shown on the Layout Drawing dated November 24, 2006, approved by this Certificate;

“Professional Engineer” means Professional Engineer as defined in the Professional Engineers Act;

"Provincial Officer" means any person designated in writing by the Minister as a provincial officer pursuant to section 5 of the OWRA or section 5 of the EPA or section 17 of PA;

"Publication NPC-205" means the Ministry Publication NPC-205, “Sound Level Limits for Stationary Sources in Class 1 & 2 Areas (Urban)”, October, 1995;

"Receiving Room" means the room used for various material handling, processing and storage operations, as shown on the Layout Drawing dated November 24, 2006, approved by this Certificate;

“Recyclables” means glass and metallic objects;

"Regulation 347" means Ontario Regulation 347, R.R.O 1990 (General –Waste Management) enacted under the EPA, as amended from time to time;

“Regulation 419/05" means Ontario Regulation 419/05 enacted under the EPA, as amended from time to time;

"Schedules" means the schedules attached to the Certificate and forming part of this Certificate;

“Scrubber” means the venturi scrubber described in the Application for a Certificate of Approval as approved by this Certificate;

"Site" means the property leased by the City to the Owner for operation of the Pilot Plant, located at 402 Fifth Line East in Sault Ste. Marie, approved by this Certificate and the Waste Certificate;

"Source Testing" means sampling and analysis of gaseous flows for the purpose of determining compliance with the EPA and the regulations written under it and the requirements of this Certificate;

“Spent Activated Carbon Filter” means an activated carbon that has been removed from service;

“Spent HEPA Filter” means a high efficiency particulate air filter that has been removed from service;

"Supporting Documentation" means the documents listed in Schedule "A" of this Certificate;

"Test Contaminants" means the compounds listed in Schedules 1 to 5 inclusive to be measured during Source Testing required by this Certificate;

"Trained personnel" means personnel knowledgeable in the following through instruction and practice:

a. relevant legislation, regulations and guidelines;

b. major environmental concerns pertaining to the materials to be handled;

c. occupational health and safety concerns pertaining to the processes and materials to be handled;

d. emergency management procedures for the process and materials to be handled;

e. operation of the equipment to be used;

f. emergency response procedures;

g. company specific written procedures for the control of nuisance conditions;

h. the requirements of this Certificate;

“Undiluted gases” means the gas stream which contains oxygen, nitrogen, hydrogen, carbon monoxide, total hydrocarbons and all contaminants in the same concentrations as they exist in the gas stream emerging from an individual piece of equipment and into which gas stream no ambient air and/or no other gas stream originating from another piece of equipment has been introduced;

“waste certificate” means the provisional certificate of approval for a waste disposal site issued in accordance with section 39 of the EPA for the same equipment and for the same experiments as the ones covered by this Certificate, and includes any schedules to it;

“woodwaste” has the same meaning as in Regulation 347.

You are hereby notified that this approval is issued to you subject to the terms and conditions outlined below:

TERMS AND CONDITIONS

Compliance

1. The Owner and Operator shall ensure compliance with all the conditions of this Certificate and the Waste Certificate and shall ensure that any person authorized to carry out work on or operate any aspect of the Pilot Plant is notified of this Certificate and the Waste Certificate and the conditions herein and shall take all reasonable measures to ensure any such person complies with the same.
2. Any person authorized to carry out work on or operate any aspect of the Pilot Plant shall comply with the conditions of this Certificate and the Waste Certificate.

Build, etc. in Accordance

3. Except as otherwise provided by this Certificate, the Pilot Plant shall be designed, developed, built, operated and maintained in accordance with the application for this Certificate and the supporting documentation listed in Schedule "A", except for minor variances in dimensions set out for stack and building heights and stack diameters.

As-built Drawings

4. The Owner shall provide to the Director and District Manager copies of as-built construction layout drawings bearing the stamp of a Professional Engineer prior to any waste being received at the Pilot Plant. An amendment to this Certificate shall be sought for changes requiring approval.

Interpretation

5. Where there is a conflict between a provision of any document, including the application, referred to in this Certificate, and the conditions of this Certificate, the conditions in this Certificate shall take precedence.

6. Where there is a conflict between the application and a provision in any documents listed in Schedule "A", the application shall take precedence, unless it is clear that the purpose of the document was to amend the application and that the Ministry approved the amendment.

7. Where there is a conflict between any two documents listed in Schedule "A", other than the application, the document bearing the most recent date shall take precedence.

8. The requirements of this Certificate are severable. If any requirement of this Certificate, or the application of any requirement of this Certificate to any circumstance, is held invalid or unenforceable, the application of such requirement to other circumstances and the remainder of this certificate shall not be affected thereby.

Other Legal Obligations

9. The issuance of, and compliance with the conditions of, this Certificate does not:

a. relieve any person of any obligation to comply with any provision of any applicable statute, regulation or other legal requirement; or

b. limit in any way the authority of the Ministry to require certain steps be taken or to require the Owner and Operator to furnish any further information related to compliance with this Certificate.

Adverse Effects

10. The Owner and Operator shall take steps to minimize and ameliorate any adverse effect on the natural environment or impairment of water quality resulting from the Pilot Plant, including such accelerated or additional monitoring as may be necessary to determine the nature and extent of the effect or impairment.

11. Despite an Owner, Operator or any other person fulfilling any obligations imposed by this certificate the person remains responsible for any contravention of any other condition of this Certificate or any applicable statute, regulation, or other legal requirement resulting from any act or omission that caused the adverse effect to the natural environment or impairment of water quality.

Change of Owner

12. The Owner shall notify the Director, in writing, and forward a copy of the notification to the District Manager, within

30 days of the occurrence of any changes in the following information:

a. the ownership of the Site

b. the Operator of the Site;

c. the address of the Owner or Operator;

d. the partners, where the Owner is or at any time becomes a partnership and a copy of the most recent declaration filed under the Business Names Act, R.S.O. 1990, c. B-17 shall be included in the notification;

e. the name of the corporation where the Owner is or at any time becomes a corporation, other than a municipal corporation, and a copy of the most current information filed under the Corporations Information Act, R.S.O. 1990, c. C-39 shall be included in the notification.

Inspections

13. No person shall hinder or obstruct a Provincial Officer in the performance of his/ her duties, including any and all inspections authorized by the EPA or the OWRA of any place to which this Certificate relates, and without limiting the foregoing to:

a. Enter the Pilot Plant, or the location where the records required by the conditions of this Certificate are kept;

b. Have access to, inspect, and copy any records required by the conditions of this Certificate;

c. Inspect the practices, procedure, or operations required by the terms and conditions of this Certificate; and

d. Sample and monitor for the purposes of assessing compliance with the conditions of this Certificate or the EPA or the OWRA.

Information and Record Retention

14. Any information requested, by the Ministry, concerning the Pilot Plant and its operation under this Certificate, including but not limited to any records required to be kept by this Certificate shall be provided to the Ministry, upon request. Records shall be retained for 5 years except for as otherwise authorized in writing by the Director.

15. The receipt of any information by the Ministry or the failure of the Ministry to prosecute any person or to require any person to take any action, under this Certificate or under any statute, regulation or other legal requirement, in relation to the information, shall not be construed as:

a. An approval, waiver, or justification by the Ministry of any act or omission of any person that contravenes any term or condition of this Certificate or any statute, regulation or other legal requirement; or

b. Acceptance by the Ministry of the information's completeness or accuracy.

Notice of Commencement Date of Operation

16. The Owner shall forward to the Director and the District Manager written notification at least fifteen (15) days prior to the date when Kiln Feed is first scheduled to be received at the Pilot Plant.

Expiry

17. This Certificate shall expire on the 365th day following the Commencement Date of Operation.

Operation and Maintenance

18. The Owner shall ensure that the Pilot Plant is properly operated and maintained at all times. The Owner shall, as a minimum:

a. prepare before the Commencement Date of Operation and update, as necessary, a manual outlining the operating procedures and a maintenance program for the Pilot Plant, including:

i. routine operating procedures in accordance with recommendations of the equipment manufacturers and good engineering practices and other requirements contained in this Certificate;
ii. an odor control plan to prevent any odor from escaping the building;
iii. dust control plan to prevent any dust from escaping the building;
iv. inspection programs, including frequency of inspection of all pieces of Equipment, and the methods or tests employed to detect when maintenance is necessary;
v. repair and maintenance programs, including the frequency of routine maintenance of all pieces of Equipment;
vi. emergency procedures;
vii. instructions for any record keeping activities relating to operation, inspection and maintenance of the Equipment;
viii. any other plans and procedures which are necessary because of the special nature of the Pilot Plant, the materials used at the Pilot Plant, or the location thereof;
ix. a list of personnel positions responsible for operation and maintenance, including supervisory personnel and personnel responsible for recording and reporting pursuant to the requirements of this Certificate, along with the training and experience required for the positions and a description of the responsibilities;
x. a list and location of spare parts to be kept available at the Site;
xi. the procedures for recording and responding to environmental complaints; and
xii. all appropriate measures to minimize dust, odour, noise and other nuisances generated from all potential sources at the Pilot Plant;
b. provide the operating and maintenance manual for inspection by staff of the Ministry upon request; and

c. implement the recommendations of the operating and maintenance manual.

19. The Owner shall ensure that at all times:

a. funding, staffing, training of staff, process controls, quality assurance and quality control procedures of or in relation to the Pilot Plant are adequate to achieve compliance with this Certificate;

b. equipment and material are kept on hand and in good repair for immediate use in the event of:

i. a breakdown of the Pilot Plant or any part thereof
ii. any change in process parameters which may result in an excursion from approved operational ranges and / or may result in a discharge into the natural environment of any contaminant in an amount, concentration or level in excess of that prescribed by the regulations or imposed by this Certificate;
iii. any fire or explosion;
iv. any spill within the meaning of Part X of the EPA;
v. any other potential contingency.

20. The Owner shall conduct regular inspections of the Pilot Plant to ensure that all pieces of Equipment are maintained and operated in a manner that will not negatively impact the environment and that all materials are handled and stored in a manner that will not negatively impact the environment. Any deficiencies detected during these regular inspections, that might negatively impact the environment, shall be promptly corrected. A written record shall be prepared, which includes the following:
a. name and signature of Trained Owner representative conducting the inspection;

b. date and time of the inspection;

c. list of pieces of Equipment and areas inspected and all deficiencies that might negatively impact the environment observed;

d. recommendations for remedial action and actions undertaken;

e. date and time of maintenance activity; and

f. a detailed description of the maintenance activity.

21. The Owner shall install a new HEPA Filter and three new Activated Carbon Filters before beginning experiments with

Domestic Waste, Sewage Sludge and Paper Waste. The filters shall not be changed to new ones until the full set of experiments with each individual Kiln Feed has been completed and experiments with the next Kiln Feed are to begin, unless it is determined that the filters are so deteriorated that they are not expected to control emissions as required. If the filter change is deemed necessary, the Owner shall prepare a detailed explanation why the filters were rendered inefficient prematurely.

Emergency Power Supply:

22. The Owner shall ensure that all pieces of equipment required for Emergency Power Supply are maintained in proper working condition so that power is available at all times for the proper operation of the Kiln drive, the nitrogen purge system, the air blower for the Kiln, the Gas Treatment System, the induced draft fan, the Enclosed Flare and the Plant Logical Control system and other essential loads to ensure a safe shutdown of the Pilot Plant during external power supply failures.

Enclosed Flare Temperature, Retention Time and Turbulence:

23. The Owner shall have the Enclosed Flare designed in such a manner as to ensure that a temperature of not less than 1100^{o}C can be maintained, on a continuous basis, in the Enclosed Flare.

24. The Owner shall have the Enclosed Flare designed and operated in such a manner as to ensure that the following Performance Conditions are met at all times when Kiln Feed is in the Kiln:

a. The Enclosed Flare shall be capable of regulating, by means of auxiliary fuel and/ or air supply control, the temperature at the outlet of the Enclosed Flare, so as to ensure that a temperature of not less than 1000^{o}C is attained prior to introduction of any Kiln Feed into the Kiln during any start-up, and that the said temperature is thereafter maintained at all times when Kiln Feed is in the Kiln.

b. The Enclosed Flare shall include air control systems, which are capable of automatically adjusting the distribution and the quantity of combustion air, in such a manner that any changes in the quantity or quality of the gases entering the Enclosed Flare shall not adversely affect the performance of the Enclosed Flare.

c. The Gas Residence Time shall be a minimum of one second at a temperature of not less than 1000^{o}C, and shall be calculated from the point where most of the combustion has been completed and the combustion temperature fully developed within the Enclosed Flare to the last thermocouple, where the temperature of not less than 1000^{o}C is maintained as recorded continuously.

d. The Enclosed Flare shall be operated to provide and maintain a high degree of gas turbulence and mixing.

e. The Enclosed Flare shall achieve the temperature, Gas Residence Time, residual oxygen and turbulence requirements over the complete range of operating parameters, including Kiln Feed rate, Kiln Feed type, combustion air, gas flow rate and heat losses.

f. Compliance with the Enclosed Flare temperature limit shall be determined using the thermocouple included in the Continuous Monitoring and Control System required by this Certificate.

Process Parameter Concentration Limits

25. The Owner shall operate the Kiln and the Enclosed Flare in such a manner as to ensure that the following Performance Conditions are met at all times when Kiln Feed is gasified or thermally degraded in the Kiln:

a. The concentration of organic matter having a carbon content, expressed as equivalent methane, in the Undiluted Gases at the outlet of the Enclosed Flare and being an average of ten measurements taken at approximately one minute intervals, shall be not more than 50 parts per million by volume on dry basis;

b. The concentration of carbon monoxide, calculated as a rolling 30-minute average concentration in the Undiluted Gases at the outlet of the Enclosed Flare shall be not more than 35 parts per million by volume on dry basis; and

c. The residual oxygen, calculated as a rolling 10-minute average concentration, in the Undiluted Gases at the outlet of the Enclosed Flare shall be not less than 6 percent by volume on dry basis.

d. Compliance with the concentration limits for total hydrocarbons, carbon monoxide and oxygen, referenced in the condition above, shall be determined based on results obtained from the Continuous Monitoring and Control System required by this Certificate.

Contaminant Concentration Limits:

26. The Owner shall, at all times, operate the Kiln, the Gas Treatment System and the Enclosed Flare in such a manner as to ensure that the following Performance Conditions are met:

a. The concentration of suspended particulate matter in the Undiluted Gases at the outlet of the Enclosed Flare, shall be not more than 17 milligrams per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25^{O}C and a reference pressure of 101.3 kilopascals.

b. The toxicity equivalent concentration of Dioxins and Furans in the Undiluted Gases at the outlet of the Enclosed Flare shall be not more than 80 picograms per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25^{O}C and a reference pressure of 101.3 kilopascals. The toxicity equivalent concentration of Dioxins and Furans shall be calculated in accordance with the International Scheme set out in Schedule 2 of the Certificate.

c. The concentration of hydrochloric acid in the Undiluted Gases at the outlet of the Enclosed Flare shall be not more than 18 parts per million by volume on dry basis.

d. The concentration of oxides of nitrogen in the Undiluted Gases at the outlet of the Enclosed Flare shall be not more than 110 parts per million by volume on dry basis.

e. The concentration of sulphur dioxide in the Undiluted Gases at the outlet of the Enclosed Flare shall be not more than 21 parts per million by volume on dry basis.

f. The concentration of cadmium in the Undiluted Gases at the outlet of the Enclosed Flare while thermally degrading all other wastes except sewage sludge shall be not more than 14 micrograms per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25^{O}C and a reference pressure of 101.3 kilopascals.

g. The concentration of lead in the Undiluted Gases at the outlet of the Enclosed Flare while thermally degrading all other wastes except sewage sludge shall be not more than 142 micrograms per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25^{O}C and a reference pressure of 101.3 kilopascals.

h. The concentration of mercury in the Undiluted Gases at the outlet of the Enclosed Flare shall be not more than 20 micrograms per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25^{O}C and a reference pressure of 101.3 kilopascals while thermally degrading Domestic Waste including paper waste in the Kiln and not more than 70 micrograms per dry cubic metre normalized to 11 percent oxygen at a reference temperature of 25^{O}C and a reference pressure of 101.3 kilopascals while thermally degrading sewage sludge in the Kiln.

i. Compliance with the concentration limits for suspended particulate matter, Dioxins and Furans, cadmium, lead, mercury, sulphur dioxide and oxides of nitrogen shall be determined based on the results of the Source Testing required by this Certificate.

j. The removal efficiencies for arsenic, cadmium, chromium, lead and nickel as set out in the table below shall be met at all times when thermally degrading sewage sludge. The removal efficiencies shall be calculated based on the feed rate of each of the metals into the Kiln and the respective emission rate into the atmosphere as determined during Source Testing required by this Certificate.

Parameter	Minimum Removal Efficiency (percent by weight)
Arsenic	**99**
Cadmium	**89**
Chromium	**99**
Lead	**92**
Nickel	**99**

Cooling of Pilot Plant Gases

27. The Owner shall ensure that the temperature of the gases leaving the Scrubber does not exceed 150^{o}C.

Noise

28. The Company shall ensure that the noise emissions from the Facility comply with the limits set in Publication NPC-205.

Continuous Monitoring and Control System:

29. The Owner shall install appropriate systems to conduct and maintain a program to continuously monitor and control the temperature in the Kiln, Scrubber exhaust, the Enclosed Flare and the concentrations of oxygen, carbon monoxide and total hydrocarbons in the Undiluted Gases leaving the Enclosed Flare. The Continuous Monitoring and Control System shall be equipped with continuous recording devices and shall comply with the requirements outlined in the attached Schedules 6, 7 and 8. The Owner shall also continuously monitor the Baseline Parameters set out in Schedule 9.

30. The Owner shall develop and conduct quality assurance and quality control (QA/QC) procedures for the Continuous Monitoring and Control System in accordance with Report EPS 1/PG/7 also setting out the QA/QC procedures which will be employed for the methods and devices used to monitor the Baseline Parameters.

31. The Owner shall retain a copy of the QA/QC plan at the Site and shall comply with the said plan at all times.

Source Testing:

32. The Owner shall perform Source Testing to determine the rate of emission of Test Contaminants in the Undiluted gases leaving the Enclosed Flare while thermally degrading Domestic Waste, and sewage sludge and Paper Waste, each separately, in the natural gas fired Kiln without the addition of any reagents or other materials into the Kiln Feed.

a. The Owner shall submit to the Manager a test protocol, including the Pre-Test Information for the Source Testing required by the Source Testing Code.

b. The Owner shall finalize the test protocol in consultation with the Manager.

c. The Owner shall not commence the Source Testing until the Manager has accepted the test protocol.

d. The Owner shall complete the Source Testing with Domestic Waste during the final continuous experiment when all process parameters have been optimized.

e. The Owner shall notify the District Manager and the Manager in writing of the location, date and time of any impending Source Testing required by this Certificate, at least fifteen (15) days prior to the Source Testing.

f. The Owner shall prepare and submit to the Director and the Manager an interim report on the Source Testing carried out while thermally degrading Domestic Waste, complete with the following information:

i. Dates when the Source Testing was completed;
ii. All records of the operating conditions for the Pilot Plant during the Source Testing, including the Domestic Waste feed rate into the Kiln and the Baseline Parameters;
iii. all records of the Continuous Monitoring and Control System during the Source Testing;

iv. all results from the Source Testing for the parameters referenced in condition 25. a. to c. inclusive and condition 26. a. to h. inclusive.
g. The Owner shall not feed any other Kiln Feed into the Kiln until the Manager has determined that the interim report in condition 32.f. adequately demonstrates that the emissions and operation of the Pilot Plant during the Source Testing complied with Regulation 419/05 and this Certificate and the Waste Certificate.

h. The Owner shall carry out the Source Testing with the other Kiln Feeds during the final continuous experiment with the particular Kiln Feed when all process parameters have been optimized.

i. The Owner shall submit to the District Manager and the Manager a final report on the Source Testing involving Domestic Waste not later than three (3) months after the Commencement Date of Operation and on the Source Testing involving Paper Waste and sewage sludge not later than two (2) months after completing the Source Testing involving each of those Kiln Feeds required to be tested. The reports shall be in the format described in the Source Testing Code, and shall also include, but not be limited to:

i. an executive summary;
ii. records of all operating conditions, including type of Kiln Feed, Kiln Feed rate, analytical results for each Kiln Feed as required, calculations to determine removal efficiencies for arsenic, cadmium, chromium, lead and nickel while thermally degrading sewage sludge, all records produced by the Continuous Monitoring and Control Systems, including all values for the Baseline Parameters, as well as all operational problems that may have been encountered during the Source Testing;
iii. Where the analytical results indicate that the amount of a particular isomer of dioxins or furans is less than the detection limit reported by the laboratory analyzing the source testing samples, the Owner shall determine the amount of Dioxins and Furans to be reported as the toxicity equivalent concentration by using the reported detection limit as the amount present for that isomer. The reported detection limits are to be determined by the laboratory at the time the source testing samples are analyzed based on analysis of appropriate replicate low level samples or blanks;
iv. Confirmation of compliance with the Ministry's Guideline A-7 and Guideline A-8, as appropriate, and this Certificate, including a table that compares measured concentrations to the limits in the above Guidelines;
v. the results of dispersion calculations in accordance with O. Reg. 419/05 indicating the maximum concentration of the Test Contaminants, excluding carbon monoxide and total hydrocarbons at the Point of Impingement;
vi. the report on mercury emissions shall include total emissions as well as speciated emissions: elemental mercury and oxidized forms of mercury.
j. The Director may not accept the results of the Source Testing if:

i. the Source Testing Code or the requirements of the Manager were not followed; or
ii. the Owner did not notify the District Manager and the Manager of the Source Testing; or
iii. the Owner failed to provide a complete report on the Source Testing.

k. If the Director does not accept the results of the Source Testing, the Director may require re-testing.

Emergency Shutdown of the Pilot Plant

33. The Owner shall immediately take appropriate steps to safely shut down the Pilot Plant and forthwith cease discharging contaminants into the natural environment in the event that

a. Kiln pressure exceeds the established maximum set point;
b. Kiln temperature exceeds the maximum established set point;
c. Oxygen level in the Kiln exceeds the maximum allowable set point for a period of greater than 5 minutes;
d. there is a failure of the scrubber liquor supply to the venturi scrubber;
e. temperature of the gases leaving the Scrubber exceeds 150^{O}C;
f. the concentration of total hydrocarbons exceeds the 10-minute average concentration limit of 50 parts per million for longer than one hour;
g. the temperature of the Enclosed Flare at the point of one-second retention time is below the minimum allowable temperature of 1000 ^{O}C for longer than five minutes;
h. emergency venting through the Enclosed Flare with a bypass of the HEPA Filter and the Activated Carbon Filters occurs for any reason;
i. there is a power failure lasting longer than five minutes.

34. In the event of a power failure the Owner shall immediately cease feeding any Kiln Feed into the Kiln.

35. The Owner shall not restart the Pilot Plant until and unless the cause of the problem requiring shut down of the Pilot Plant has been determined and appropriate steps have been taken to ensure that Pilot Plant will be operated in compliance with the requirements.

Experiments with Lime and Nacholite

36. The Owner may carry out experiments by manually mixing flaked lime or nacholite (sodium bicarbonate) with wetted Domestic Waste in the Receiving Room prior to the Domestic Waste being transferred into the Process Room. The duration of the experiments shall not exceed five days per reagent provided the overall pilot testing with all Kiln Feeds does not exceed 46 weeks including the initial equipment shakedown period of two weeks with woodwaste.

Complaint Response

37. If at any time, the Owner receives any environmental complaints regarding the operation of the Equipment approved by this Certificate, the Owner shall respond to these complaints according to the following procedure:

a. The Owner shall record each complaint, either electronically or in hard copy format, and shall include the following information: time and date of the complaint, incident to which the complaint relates, the nature of the complaint, wind direction at the time of the incident, the name, address and the telephone number of the complainant, if known;
b. The Owner, upon notification of the complaint, shall initiate appropriate steps to determine all possible causes of the complaint, proceed to take the necessary actions to appropriately deal with the cause of the complaint; and
c. The Owner shall prepare and retain on-site a report written within one (1) week of the complaint date, listing the actions taken to deal with the cause of the complaint and any recommendations for remedial measures, and managerial or operational changes to reasonably avoid the reoccurrence of similar incidents.

Daily Records

38. The Owner shall ensure that daily records are maintained in written format and they include the following information:

a. Date of record;
b. description, origin, representative photograph, weight as received, moisture content for each Kiln Feed shipment, weight of Recyclables and Incidental Subject Waste in each waste feed shipment as received;
c. description, representative photograph and quantity of any waste load or part thereof refused at the Site and reasons for refusal and actions taken;
d. description, representative photograph and weight of each waste type (glass, metal, Hazardous Waste or other) removed manually from the waste before processing in the Kiln;
e. description, including amount of flaked lime or nacholite added to the Domestic Waste before feeding into the Kiln, representative photographs and weight of each Kiln Feed batch fed into the Kiln;
f. start and finish time for each experiment involving operation of the Kiln;
g. records relating to maintenance of the pilot plant as well as all process conditions, including Baseline Parameters as well as minimum, maximum and average values for each continuously monitored parameter, and all in accordance with the Operations Manual and conditions set out in both the Waste Certificate and the Air Certificate;
h. description, representative photographs and weight of each Kiln Residue removed from the Kiln after processing of each batch of Kiln Feed has been completed;
i. records relating to sampling and analyses of Kiln Residue, Spent Activated Carbon, Spent HEPA Filters and any spilled materials or other on-site generated wastes together with a confirmation by Trained personnel that the sampling was conducted in accordance with the Waste Certificate;
j. description and quantity of unprocessed waste or quantity of coal as well as Kiln Residue, Spent Activated Carbon, Spent HEPA Filters and any spilled materials or other on-site generated wastes remaining at the Site at the end of the day being recorded;
k. description, representative photograph, quantity and destination for each type of waste shipped from the Site together with results relating to the sampling and analysis of the waste;
l. record of daily inspections required by the Air Certificate and the Waste Certificate;
m. records of all maintenance and repairs carried out;
n. record of any spills or process upsets at the Site, the nature of the spill or process upset and the action taken for the

clean up of the spill or other remedial measure or corrective action, the time and date of the spill or process upset, and for spills, the time that the Ministry and other persons were notified of the spill in fulfillment of the reporting requirements in the EPA;
o. name and signature of the Trained Personnel completing the daily record.

Quarterly Engineer's Report

39. The Owner shall retain an Independent and Knowledgeable Professional Engineer for the following activities:

a. The Independent and Knowledgeable Professional Engineer shall visit the Pilot Plant at the end of each three-month period following the Commencement Date of Operation to observe and report on the operations of the Pilot Plant and to verify compliance with the conditions of this Certificate and the Waste Certificate. The inspections shall include a detailed walkthrough of the entire Pilot Plant and a thorough review of the Daily Records required by Condition 38 for the previous calendar quarter

b. The Independent and Knowledgeable Professional Engineer shall prepare a written report summarizing the results of each inspection complete with his/ her signature certifying whether the Pilot Plant has been operated in substantial compliance with this Certificate and the Waste Certificate since the previous report. This report must be available for inspection by Ministry staff not later than ten business days following the end of the calendar quarter being reported on.

c. The Independent and Knowledgeable Professional Engineer shall immediately notify the Owner in writing with a copy to the District Manager in the event that non-compliance is observed during the course of the inspection.

d. In the event that the Owner becomes aware of non-compliance either through the notification of the Independent and Knowledgeable Professional Engineer or otherwise, the Owner shall forthwith take action to bring the Pilot Plant to compliance and report to the District Manager in writing of the actions taken.

Pilot Plant Final Report

40. The Owner shall prepare a written report on the operation of the Pilot Plant and shall have it audited by the Independent and Knowledgeable Professional Engineer. The Report shall be submitted to the District Manager not later than six months after the expiry of this Certificate. The report shall include, as a minimum, the following information:

a. detailed monthly summaries for all Kiln Feeds, including dates, types and quantities, transferred to the Site and all loads of Kiln Feed or parts thereof refused to be accepted at the Site as well as destinations for all refused loads of Kiln Feed and any wastes generated at the Site and transferred from the Site;
b. monthly summaries of the records produced by the continuous monitoring and control systems, including dates, duration and reasons for any excursions from limits set out in this Certificate and actions taken to prevent future excursions;
c. detailed records in accordance with the Operations Manual, this Certificate and the Waste Certificate with regard to each experiment involving any Kiln Feed carried out at the Site;
d. details of all repair and maintenance activities at the Site;
e. dates of all environmental complaints relating to the Site together with cause of the complaints and actions taken to prevent future complaints and/ or events that could lead to complaints ;
f. dates and duration of all power failures between the Commencement Date of Operation and the Closure of the Site;
g. any environmental and operational problems that could have negatively impacted the environment, discovered as a result of daily inspections or otherwise and any mitigative actions taken;
h. any changes to the Emergency Response and Contingency Plan, the Design and Operations Report and the Closure Plan that have been approved by the Director since the issuance of this Certificate; and
i. any recommendations to improve the environmental and process performance of the Pilot Plant or a similar plant in the future;
j. statement of compliance with this Certificate and the Waste Certificate, including compliance with Regulation 419/05 and all air emission limits set out in this Certificate based on the results of source testing, continuous monitoring and engineering calculations, as may be appropriate;
k. an evaluation of the ability and feasibility of the Pilot Plant to produce a gaseous stream that may be used as fuel in a combustion device for the purpose of recovering its energy content;

l. signature of the Trained Owner representative responsible for the Summary Report;
m. signature of the Independent and Knowledgeable Professional Engineer who audited the Summary Report, together with his or her comments and recommendations for possible future tests or other projects.

SCHEDULE "A"

This Schedule "A" forms part of Certificate:

1. Application for a Provisional Certificate of Approval (Air), dated July 4, 2006, signed by Jayson Zwierschke, together with Appendices A- J inclusive.
2. A letter, dated July 11, 2006, signed by Jayson Zwierschke, together with the following attachments:
    - Attachment 1, Executive Summary, dated July 11, 2006
    - Attachment 2, Enquest Response to MOE review Notes (June), Parts 4.1, 4.2, 4.3 and 4.4, dated July 11, 2006
    - Attachment 6, Public Consultation Documents
    - Attachment 7, Detailed Test Program Summary, original dated June 25, 2006
    - Attachment 9, Key Equipment List, Details and Drawing Copies, dated July 4, 2006
    - Attachment 10, Key Equipment Operations Summaries, dated July 4, 2006
    - Attachment 14, Health, Safety and Emergency Response Manual
    - Operations Manual, Technology Demonstrator, Steam Reforming System, stamped received on July 14, 2006, including Operating Manual and Safety Procedures for Indirectly Heated Kiln, Induction Kiln System, Shredder, Steam Generator, Back Up Electric Generator (Natural Gas), Syngas Enclosed Burner, Odor Control System, Agilent Data System and Scrubber System.
3. E-mail from Ernie Dueck to Anne-Maria Pennanen dated October 2, 2006 in response to Ministry's letter of July 24, 2006;
4. E-mail from Ernie Dueck to Anne-Maria Pennanen dated October 2, 2006, together with filter specifications.
5. E-mail from Ernie Dueck to Anne-Maria Pennanen dated October 6, 2006, together with attachments relating to emission calculations.
6. E-mail from Ernie Dueck to Anne-Maria Pennanen dated October 13, 2006, together with attachments relating to emission calculations.
7. E-mail from Ernie Dueck to Anne-Maria Pennanen dated October 15, 2006, together with attachments relating to emission calculations.
8. E-mail from Ernie Dueck to Anne-Maria Pennanen dated November 17, 2006 providing additional operationsal details together with a clarification document dated November 16, 2006.
9. E-mail dated November 24, 2006 together with revised Layout Drawing dated November 24, 2006
10. E-mail dated November 27, 2006 together with revised Test Schedule dated November 18, 2006
11. E-mail from Ernie Dueck to Anne-Maria Pennanen dated November 27, 2006 providing a draft letter dated November 27, 2006 together with a four-page addendum also referencing the final revisions of documents listed therein, including flare calculations dated September 9, 2006 as revised on November 27, 2006; flare drawing dated October 28, 2006; revised dispersion modelling dated September 30, 2006; documents relating to emission calculations dated October 12, 2006, October 15, 2006; revised Process Flow Diagram dated October 7, 2006.
12. A letter dated November 29, 2006, signed by Ernie Dueck together with a letter dated November 27, 2006, also signed by Ernie Dueck as well as a a four-page addendum and hardcopies of previous electronic submissions.

SCHEDULE 1

This **Schedule 1** forms part of this Certificate

<u>Gases and Particulate</u>

1. Gases:

Hydrogen Chloride
Carbon Monoxide
Carbon Dioxide
Oxides of Nitrogen
Oxygen
Sulphur Dioxide
Total Hydrocarbons
Mercury*

2. Particulate

PM 2.5, PM 10, total suspended particulate matter and fractions in the suspended particulate matter for the following materials:

Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Fluorides, Iron, Lead, Lithium, Magnesium, Manganese, Mercury*, Molybdenum, Nickel, Phosphorous, Selenium, Silicon, Silver, Sodium, Strontium, Tin, Titanium, Vanadium, Zinc

* The Owner shall ensure that mercury emissions are tested in accordance with the Ontario Hydro method developed for speciation of mercury emissions.

SCHEDULE 2

This Schedule 2 forms part of Certificate of Approval (Air).

Table A: **CALCULATION OF TOXICITY EQUIVALENT DIOXIN AND FURAN CONCENTRATION**

Dioxin/Furan Isomers of Concern	**International Toxicity Equivalency Factors (I-TEF's)**	**Concentration pg/m3 (Analytically measured)**	**Toxicity Equivalent (TEQ) pg TEQ/m3**
A	**B**	**C**	**D** (D = B x C)
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1		
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	0.5		
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	0.1		
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	0.1		
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	0.1		
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	0.01		
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	0.001		
2,3,7,8-Tetrachlorodibenzofuran	0.1		
2,3,4,7,8-Pentachlorodibenzofuran	0.5		
1,2,3,7,8-Pentachlorodibenzofuran	0.05		
1,2,3,4,7,8-Hexachlorodibenzofuran	0.1		
1,2,3,6,7,8-Hexachlorodibenzofuran	0.1		
1,2,3,7,8,9-Hexachlorodibenzofuran	0.1		
2,3,4,6,7,8-Hexachlorodibenzofuran	0.1		
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.01		

1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.01		
1,2,3,4,6,7,8,9-Octachlorodibenzofuran	0.001		
TOTAL TOXICITY EQUIVALENT			

NOTE: TOTAL TOXICITY EQUIVALENT in the above Table A of Schedule 2 is the sum of toxicity equivalent concentrations of individual isomers.

The above Table A of Schedule 2 is intended to assist in the calculation required to obtain a toxicity equivalent concentration of emissions that contain various polychlorinated dioxin and furan isomers (compounds).

In order to calculate a concentration that reflects the overall toxicity of the dioxin and furan emissions from a source, International Toxicity Equivalency Factors (I-TEFs) are applied to 17 dioxins and furan isomers of concern set out in Column A of Table A. The most toxic of all dioxin and furan isomers is 2,3,7,8-TCDD (tetrachlorodibenzo-p-dioxin) and therefore its I-TEF is identified as 1.0 in Column B of Table A. The toxicity of the other dioxin and furan isomers is identified in Column B of Table A relative to 2,3,7,8-TCDD. For instance, 2,3,4,7,8-Pentachlorodibenzofuran is half as toxic as 2,3,7,8-TCDD and therefore its I-TEF is 0.5.

The actual toxicity equivalent concentration (TEQ; to be inserted in Column D) of each isomer in relation to 2,3,7,8-TCDD is calculated by multiplying the measured concentration of the isomer (to be inserted in Column C) by the I-TEF of that isomer (set out in Column B). The measured concentration to be inserted in Column C is the concentration that has been calculated based on sampling and analysis of a gas stream as part of a source testing campaign.

The total toxicity equivalent concentration of Dioxins and Furans discharged in the gas stream from a source is then obtained by summing up all of the individual TEQ values in Column D for each of the isomers of concern in Column A as shown at the bottom of Column D (TOTAL TOXICITY EQUIVALENT).

Compliance with the stack concentration limit for dioxin and furan emissions is achieved if the calculated TOTAL TOXICITY EQUIVALENT is less than the limit set out in this Certificate (the toxicity equivalent concentration of Dioxins and Furans in the Undiluted Gases at the outlet of the Enclosed Flare). A similar approach shall be used to assess whether or not the measured emissions, as applied in a dispersion model, comply with the Point of Impingement concentration limit for Dioxins and Furans.

The above I-TEF scheme is intended to be used with isomer specific analytical results. In cases where results are reported by congener group only, staff at the Ministry's Standards Development Branch should be contacted for appropriate procedures to convert non-isomer specific data to TEQs.

SCHEDULE 3

This **Schedule** 3 forms part of Certificate of Approval (Air)

Testing for Other Chlorinated Organics

Total Dichlorobenzenes
Total Trichlorobenzenes
Total Tetrachlorobenzenes
Pentachlorobenzene
Hexachlorobenzene

Total Dichlorophenols
Total Trichlorophenols
Total Tetrachlorophenols
Total Pentachlorophenols

Total Polychlorinated Biphenyls

SCHEDULE 4

This **Schedule 4** forms Part of Certificate of Approval (Air)

Polycyclic Organic Matter

Acenaphthylene Acenaphthene Anthracene Benzo(a)anthracene Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(a)fluorene Benzo(b)fluorene Benzo(ghi)perylene Benzo(a)pyrene Benzo(e)pyrene 2-chloronaphthalene Chrysene Coronene Dibenzo(a,c)anthracene 9,10 - Dimethylanthracene 7,12 - Dimethylbenzo(a)anthracene Fluoranthene Fluorene Indeno(1,2,3 - Cd)pyrene	2 - Methylanthracene 3 - Methylcholanthrene 1 - Methylnaphthalene 2 - Methylnaphthalene 1 - Methylphenanthrene 9 - Methylphenanthrene Naphthalene Perylene Phenanthrene Picene Pyrene Tetralin Triphenylene Dibenzo(a,h)anthracene Dibenzo(a,e)pyrene Quinoline Biphenyl O-terphenyl M-terphenyl P-terphenyl

SCHEDULE 5

This **Schedule 5 f**orms Part of Certificate of Approval (Air)

Volatile Organic Matter

Acetaldehyde
Acetone
Acrolein
Benzene
Bromodichloromethane
Bromoform
Bromomethane
Butadiene, 1,3 -
Butanone, 2 -
Carbon Tetrachloride
Chloroform
Cumene
Dibromochloromethane
Dichlorodifluoromethane
Dichloroethane, 1,2 -
Dichloroethene, Trans - 1,2 -
Dichloroethene, 1,1 -
Dichloropropane, 1,2 -
Ethylbenzene
Ethylene Dibromide

Formaldehyde
Mesitylene
Methylene Chloride
Styrene
Tetrachloroethene
Toluene
Trichloroethane, 1,1,1 -
Trichloroethene
Trichloroethylene, 1,1,2 -
Trichlorofluoromethane
Trichlorotrifluoroethane
Vinyl Chloride
Xylenes, M-, P- and O-

SCHEDULE 6

This Schedule 6 forms part of Certificate of Approval (Air)

PARAMETER: Temperature

LOCATION:
The sample point for the Continuous Temperature Monitor shall be located at the exit of the Enclosed Flare where the retention time of flue gases has reached a minimum of one second at a minimum temperature of 1000^{O}C as well as in the Kiln and at the exit of the Scrubber, as a minimum.

PERFORMANCE:
The Continuous Temperature Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS SPECIFICATION

1. Type: shielded "K" type thermocouple, or equivalent.
2. Accuracy: ± 1.5 percent of the minimum gas temperature

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor without a significant loss of accuracy and with a time resolution of one minute or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 95 percent of the time for each calendar quarter, excluding calibration time.

SCHEDULE 7

This Schedule 7 forms part of Certificate of Approval (Air)

PARAMETER: Oxygen

INSTALLATION:
The Continuous Oxygen Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of oxygen in the undiluted gases leaving the Enclosed Flare and shall meet the following installation specifications.

PARAMETERS SPECIFICATION

1. Range (percentage): 0 - 20 or 0 - 25
2. Calibration Gas Ports: close to the sample point

PERFORMANCE:
The Continuous Oxygen Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS SPECIFICATION

1. Span Value (percentage): 2 times the average normal concentration of the source
2. Relative Accuracy: ≤10 percent of the mean value of the reference method test data
3. Calibration Error: 0.25 percent O2
4. System Bias: ≤4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check: all system components checked
6. Zero Calibration Drift (24-hour): ≤0.5 percent O2
7. Span Calibration Drift (24-hour): ≤0.5 percent O2
8. Response Time (90 percent response to a step change): ≤90 seconds
9. Operational Test Period: ≥168 hours without corrective maintenance

CALIBRATION:
Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter, excluding calibration time.

SCHEDULE 8

This Schedule 8 forms part of this Certificate (Air)

PARAMETER: Carbon Monoxide

INSTALLATION:

The Continuous Carbon Monoxide Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of carbon monoxide in the undiluted gases leaving the Enclosed Flare and shall meet the following installation specifications.

PARAMETERS SPECIFICATION

1. Range (parts per million, ppm): 0 to ≥100 parts per million by volume dry
2. Calibration Gas Ports: close to the sample point

PERFORMANCE:
The Continuous Carbon Monoxide Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS SPECIFICATION

1. Span Value (nearest ppm equivalent): 2 times the average normal concentration of the source

2. Relative Accuracy: ≤10 percent of the mean value of the reference method test data or ± 5 ppm whichever is greater
3. Calibration Error: ≤ 2 percent of actual concentration
4. System Bias: ≤4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check: all system components checked
6. Zero Calibration Drift (24-hour): ≤5 percent of span value
7. Span Calibration Drift (24-hour): ≤5 percent of span value
8. Response Time (90 percent response to a step change): ≤90 seconds
9. Operational Test Period: ≥168 hours without corrective maintenance

CALIBRATION:
Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter, excluding calibration time.

SCHEDULE 9

This Schedule 9 forms part of Certificate of Approval (Air)

PARAMETER:
Total Hydrocarbons (Organic Matter)

INSTALLATION:
The Total Hydrocarbons Monitor shall be installed at an accessible location where the measurements are representative of the undiluted hydrocarbon concentrations of the gases leaving the Equipment and shall meet the following installation specifications.

PARAMETERS SPECIFICATION

1. Detector Type: Flame Ionization
2. Oven Temperature: 160 degrees Celsius minimum
3. Flame Temperature: 1800 degrees Celsius minimum at the corona of the hydrogen flame
4. Range (parts per million, ppm): 0 to 200
5. Calibration Gas: propane in air or nitrogen
6. Calibration Gas Ports: close to the sample point

PERFORMANCE:
The Continuous Total Hydrocarbon Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS SPECIFICATION

1. Span Value (nearest ppm equivalent): 2 times the average normal concentration of the source
2. Relative Accuracy: ≤ 10 percent of the mean value of the reference method test data or ± 5 ppm whichever is greater
3. System Bias: ≤ 4 percent of the mean value of the reference method test data
4. Noise: ≤ 1 percent of span value on most sensitive range
5. Repeatability: ≤ 1 percent of span value
6. Linearity (response with propane in air): ≤ 3 percent of span value over all ranges
7. Calibration Error: ≤ 2 percent of actual concentration
8. Procedure for Zero and Span Calibration Check: all system components checked on all ranges

9. Zero Calibration Drift (24-hours): ≤ 2.5 percent of span value on all ranges
10. Span Calibration Drift (24-hours): ≤ 2.5 percent of span value
11. Response Time (90 percent response to a step change): ≤ 60 seconds
12. Operational Test Period: ≥ 168 hours without corrective maintenance

CALIBRATION:
Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

SCHEDULE 10

This Schedule 10 forms part of this Certificate (Air)

Baseline Parameters and Alarms:

The Owner shall ensure that appropriate equipment and systems are available to continuously monitor and provide visual and/ or audible alarms for the following parameters as a minimum:

PARAMETER TO BE MONITORED	MINIMUM DATA RECORDING CAPABILITY	ALARM or ACTION LEVEL
Feed rate into kiln	hourly	maximum allowable feed rate
material handling system failure	as it occurs	upon failure
Kiln blower speed	Every 15 minutes	upon failure
Nitrogen flow into Kiln	as it occurs	Below minimum
Kiln internal pressure	Every 15 minutes	high
Kiln temperatures (T)	every minute	high
Kiln oxygen (O2) level	every two minutes	High O2
Enclosed Flare temperatures (T)	every minute	low T
failure of the burner flame in the Enclosed Flare	as it occurs	upon failure
oxygen (O2) concentration in the Enclosed Flare exhaust	every two minutes	Low O2
carbon monoxide (CO) concentration in the Enclosed Flare exhaust	every two minutes	high CO
Total hydrocarbon (THC) concentration in the Enclosed Flare exhaust	every minute	High THC
Water Jacket exit temperature (T)	Every minute	High T
Venturi scrubber: gas temperature at exit	Every minute	high
Venturi scrubber: scrubber liquor flow rate	every 15 minutes	low
Venturi scrubber: line pressure at all spray nozzles	every 15 minutes	upon failure

Venturi scrubber: inlet temperature of the scrubber liquor	every 15 minutes	high
Venturi scrubber: outlet temperature of the scrubber liquor	every 15 minutes	high
Venturi scrubber: pH of the scrubber liquor	every 15 minutes	low
Venturi scrubber: differential pressure drop across the venturi throat	every 15 minutes	Outside predetermined range
Venturi scrubber: visual estimate of the turbidity of the scrubber liquid	Every two hours	high
HEPA filter: pressure drop across	daily	Low/ high
Activated Carbon Filter: pressure drop across	daily	Low/ high
ID fan failure	as it occurs	upon failure
Plant Control System failure	as it occurs	upon failure

The set points for those parameters, for which this Certificate does not stipulate any value or that require an action level set point and alarm, shall be established initially before the Commencement Date of Operation of the Equipment and then refined not later than during the first sampling campaign after the Commencement Date of Operation.

All monitoring systems shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the operation, excluding calibration time.

The Baseline Parameter monitoring is a requirement that relates to the environmental performance of the Pilot Plant. Owner will conduct additional monitoring and recording to gather the required information for process/ equipment development and optimization purposes.

The reasons for the imposition of these terms and conditions are as follows:

1. The reason for Conditions 1, 2, 9, 14, 15 and 16 is to clarify the legal rights and responsibilities of the Owner and Operator.
2. The reason for Condition 4 is to ensure the availability of accurate records for inspection and information purposes.
3. The reason for Conditions 5 - 8 is to clarify what is approved.
4. Conditions 10, 11 and 37 are included to outline the minimum performance requirements considered necessary to prevent an adverse effect resulting from the operation of the Pilot Plant.
5. The reason for Condition 12 is to ensure that the Site is operated under the corporate name which appears on the application form submitted for this approval, to ensure that the Director is informed of any changes and to ensure that the former owners and/or operators of the Site are not involved in any aspect of the charge, management or control of the Site.
6. The reason for Condition 13 is to ensure that appropriate Ministry staff have ready access to the Site for inspection of facilities, equipment, practices and operations required by the conditions in this Certificate of Approval. This condition is supplementary to the powers of entry afforded a Provincial Officer pursuant to the EPA and OWRA.
7. The reason for Conditions 3, 17 and 36 is to ensure that the Site is operated in accordance with the applications and supporting documentation submitted by the Owner, and not in a manner which the Director has not been asked to consider.
8. Conditions 18 - 28 and 33 - 35 are included to emphasize that the Pilot Plant must be operated and maintained according to a procedure that will result in compliance with the EPA, the regulations and this Certificate.
9. Conditions 29 - 32 are included to require the Owner to gather accurate information so that the environmental impact and subsequent compliance with the EPA, the regulations and this Certificate can be verified.
10. Conditions 38, 39 and 40 are included to require the Owner to prepare records and to provide information to the Ministry so that the environmental impact and subsequent compliance with the EPA, the regulations and this Certificate can be verified.
11.

In accordance with Section 139 of the Environmental Protection Act, R.S.O. 1990, Chapter E-19, as amended, you may by written Notice served upon me, the Environmental Review Tribunal and in accordance with Section 47 of the Environmental Bill of Rights, S.O. 1993, Chapter 28, the Environmental Commissioner, within 15 days after receipt of this Notice, require a hearing by the Tribunal. The Environmental Commissioner will place notice of your appeal on the Environmental Registry. Section 142 of the Environmental Protection Act, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the works are located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

The Secretary* Environmental Review Tribunal 2300 Yonge St., Suite 1700 P.O. Box 2382 Toronto, Ontario M4P 1E4	AND	The Environmental Commissioner 1075 Bay Street, 6th Floor Suite 605 Toronto, Ontario M5S 2B1	AND	The Director Section 9, *Environmental Protection Act* Ministry ofthe Environment 2 St. Clair Avenue West, Floor 12A Toronto, Ontario M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

This instrument is subject to Section 38 of the Environmental Bill of Rights, that allows residents of Ontario to seek leave to appeal the decision on this instrument. Residents of Ontario may seek leave to appeal within 15 days from the date this decision is placed on the Environmental Registry. By accessing the Environmental Registry at www.ene.gov.on.ca, you can determine when the leave to appeal period ends.

The above noted works are approved under Section 9 of the Environmental Protection Act.

DATED AT TORONTO this 4th day of December, 2006

Victor Low, P.Eng.
Director
Section 9, *Environmental Protection Act*

AP/
c: District Manager, MOE Sault Ste. Marie
Jamie Bakos, Giffels Associates Limited

APPENDIX E-6

Liberty Energy Inc. Energy-from-Waste Facility, Hamilton, ON

CONTENT COPY OF ORIGINAL

Ontario

Ministry of the Environment | **Ministère de l'Environnement**

CERTIFICATE OF APPROVAL
AIR
NUMBER 9824-797JUQ
Issue Date: September 22, 2008

Liberty Energy Inc.
10 George Street, 4th Floor
Hamilton, Ontario
L8P 1C8

Site Location: Liberty Energy Centre
675 Strathearne Avenue
Hamilton City, Ontario

You have applied in accordance with Section 9 of the Environmental Protection Act for approval of:

Description Section

An Energy-From-Waste Site (Electricity Generation and Waste Disposal Site), having a name plate capacity of 10 megawatts of electricity, the electricity being generated by the gasification of biosolids and biomass, consisting of the following processes and support units:

- receipt, processing and screening of biomass and receipt of biosolids in one (1) totally enclosed building kept under negative pressure, and storage of biomass in the same building and storage of biosolids in storage silos. There is a biofilter to treat all or part of the air from the building for odour control;

- gasification of biosolids and biomass in two (2) gasification trains installed in two (2) phases, to produce steam to feed two (2) condensing steam turbines with a combined name plate capacity of 10 megawatts of electricity. Each gasification train consists of the following equipment:

- one (1) fluidized bed reactor, for gasification of the biomass and biosolids;
- one (1) waste heat boiler, to recover the heat from the flue gases of the fluidized bed reactor to produce steam; and
- one (1) flue gas pollution control train, for removal of acid gases, mercury, dioxins and furans, particulate matter, and nitrogen oxides from the flue gas;

including the *Equipment* and any other ancillary and support processes and activities, **operating at a *Facility Production Limit* of up to 1,089 tonnes per day of biosolids and 417 tonnes per day of biomass or 544 tonnes per day of biosolids and 448 tonnes per day of biomass processed and a name plate capacity of 10 megawatts of electricity** exhausting to the atmosphere as described in the *ESDM Report.*

For the purpose of this Certificate of Approval and the terms and conditions specified below, the following definitions apply:

1. *"Acoustic Assessment Report"* means the report, prepared in accordance with *Publication NPC-233* and Appendix A of the *Basic Comprehensive User Guide,* by Conestoga-Rovers & Associates and dated January 2008, submitted in support of the application, that documents all sources of noise emissions and *Noise Control Measures* present at the *Facility* and includes all up-dated *Acoustic Assessment Reports* as required by the Documentation Requirements conditions of this *Certificate* to demonstrate continued compliance with the *Performance Limits* following the implementation of any *Modification.*

2. *"Acoustic Assessment Summary Table"* means a table prepared in accordance with the *Basic Comprehensive User Guide* summarising the results of the *Acoustic Assessment Report,* up-dated as required by the Documentation Requirements conditions of this *Certificate.*

3. *"Air Standards Manager"* means the Manager, Human Toxicology and Air Standards Section, Standards Development Branch, or any other person who represents and carries out the duties of the Manager, Human Toxicology and Air Standards Section, Standards Development Branch, as those duties relate to the conditions of this *Certificate.*

4. *"AERMOD"* means the dispersion model developed by the American Meteorological Society/U.S. Environmental Protection Agency Regulatory Model Improvement Committee (AERMIC) including the PRIME (Plume Rise Model Enhancement) algorithm, used to calculate one-hour average concentrations of a contaminant at the *Point of Impingement* and at the most impacted *Sensitive Receptor.*

5. *"Basic Comprehensive User Guide"* means the *Ministry* document titled "Basic Comprehensive Certificates of Approval (Air) User Guide" dated April 2004 as amended.

6. *"Biofilter"* means the one (1) biofilter described in this *Certificate* and in the supporting documentation referred to herein, to the extent approved by this *Certificate.*

7. *"CEM System"* means the continuous monitoring system described in Schedule "C", used to continuously monitor the performance and emissions of the two (2) gasification trains in the *Facility.*

8. *"Certificate"* means this entire certificate of approval document, issued in accordance with section 9 of the *EPA* and includes all the *Schedules,* and the *Supporting Documentation.*

9. *"Commercial Operation Date"* means the date defined in the Ontario Power Authority Renewable Energy Standard Offer Program, Program Rules, version 2.0, as amended, as applied to the *Facility.*

10. *"Company"* means Liberty Energy Inc. that is responsible for the construction or operation of the *Facility* and includes any successors and assigns.

11. *"Compound of Concern"* means a contaminant that, based on generally available information, may be emitted to the atmosphere in a quantity from any source at the *Facility* that is significant either in comparison to the relevant *Ministry Point of Impingement Limit* or if a *Ministry Point of Impingement Limit* is not available for the compound then, based on generally available toxicological information, the compound has the potential to cause an adverse effect as defined by the *EPA* at a *Point of Impingement.*

12. *"Description Section"* means the section on page one of the *Certificate* describing the *Company's* operations and the *Equipment* located at the *Facility* and specifying the *Facility Production Limit* for the *Facility.*

13. *"Director"* means any person appointed in writing by the Minister of the Environment pursuant to section 5 of the *EPA* as a Director for the purposes of section 9 of the *EPA.*

14. *"District Manager"* means the District Manager of the appropriate local district office of the *Ministry,* where the *Facility* is geographically located.

15. *"Dust Management Plan"* means a document or a set of documents that provides written instructions to staff of the *Company* for the purpose of meeting the requirements of terms and conditions 6.1(h) in this *Certificate.*

16. *"Emission Summary Table"* means the table prepared in accordance with *O. Reg. 419/05* and the *Procedure Document* listing the appropriate *Point of Impingement* concentrations of each *Compound of Concern* from the *Facility* and providing comparison to the corresponding *Ministry Point of Impingement Limit* or *Maximum Concentration Level Assessment.*

17. *"Environmental Assessment Act"* means the Environmental Assessment Act, R.S.O. 1990, c.E.18.

18. *"EPA"* means the Environmental Protection Act, R.S.O. 1990, c.E.19.

19. *"Equipment"* means equipment or processes described in the *ESDM Report,* this *Certificate* and in the *Supporting Documentation* referred to herein and any other equipment or processes.

20. *"Equipment with Specific Operational Limits"* means the two (2) fluidized bed reactors and any *Equipment* related to the thermal oxidation of waste or any other *Equipment* that is specifically referenced in any published *Ministry* document that outlines specific operational guidance that must be considered by the *Director* in issuing of a Certificate of Approval.

21. *"ESDM Report"* means the Emission Summary and Dispersion Modelling Report prepared in accordance with the *Procedure Document* by Conestoga-Rovers & Associates and dated April 2008 submitted in support of the application, and includes any amendments to the ESDM Report submitted afterwards to the *Ministry* as listed in Schedule "A" and all updated ESDM Reports prepared as required by the Documentation Requirements conditions of this *Certificate.*

22. *"Facility"* means the entire operation located on the property where the *Equipment* is located.

23. *"Facility Production Limit"* means the production limit placed on the main product(s) or raw materials used by the *Facility* that represents the design capacity of the *Facility* and assists in the definition of the operations approved by the *Director.*

24. *"Independent Acoustical Consultant"* means an Acoustical Consultant not currently representing the *Company,* and not involved in the noise impact assessment or the design/implementation of noise control measures for the *Facility/Equipment.*

The *Independent Acoustical Consultant* shall not be retained by the consultant involved in the noise/vibration impact assessment or the design/implementation of noise/vibration control measures for the *Facility/Equipment.*

25. *"Log"* means the up-to-date log that is used to track all *Modifications* to the *Facility* since the date of this *Certificate* as required by the Documentation Requirements conditions of this *Certificate.*

26. *"Manager"* means the Manager, Technology Standards Section, Standards Development Branch of the *Ministry,* or any other person who represents and carries out the duties of the Manager, as those duties relate to the conditions of this *Certificate.*

27. *"Manual"* means a document or a set of documents that provides written instructions to staff of the *Company.*

28. *"Maximum Concentration Level Assessment"* means the Maximum Concentration Level Assessment for the purposes of a Basic Comprehensive Certificate of Approval, described in the *Basic Comprehensive User Guide,* prepared by a *Toxicologist* using currently available toxicological information, that demonstrates that the concentration at any *Point of Impingement* for a *Compound of Concern* that does not have a *Ministry Point of Impingement Limit* is not likely to cause an adverse effect as defined by the *EPA.* The concentration at *Point of Impingement* for a *Compound of Concern* must be calculated in accordance with *O. Reg. 419/05.*

29. *"Ministry"* means the ministry of the government of Ontario responsible for the *EPA* and includes all officials, employees or other persons acting on its behalf.

30. *"Ministry Point of Impingement Limit"* means the appropriate Standard from Schedule 1, 2 or 3 from *O. Reg. 419/05* and if a standard is not provided for a *Contaminant of Concern* the appropriate criteria listed in the Ministry publication titled "Summary of Standards and Guidelines to support Ontario Regulation 419/05: Air Pollution - Local Air Quality (including Schedule 6 of O. Reg. 419 on Upper Risk Thresholds)", dated February 2008, as amended.

31. *"Modification"* means any construction, alteration, extension or replacement of any plant, structure, equipment, apparatus, mechanism or thing, or alteration of a process or rate of production at the *Facility* that may discharge or alter the rate or manner of discharge of a *Compound of Concern* to the atmosphere or discharge or alter noise or vibration emissions from the *Facility.*

32. *"Noise Control Measures"* means measures to reduce the noise emissions from the *Facility* and/or *Equipment* including, but not limited to, silencers, acoustic louvres, enclosures, absorptive treatment, plenums and barriers.

33. *"O. Reg. 419/05"* means the Ontario Regulation 419/05, Air Pollution – Local Air Quality, as amended.

34. *"Odour Management Plan"* means a document or a set of documents that provides written instructions to staff of the

Company for the purpose of meeting the requirements of terms and conditions 6.1(g) in this *Certificate.*

35. *"Operating Envelope"* means the limits on the *Company's* approved operations set out in Conditions 2.3 to 2.7 of this *Certificate.*

36. *"Performance Limits"* means the performance limits specified in the section of this *Certificate* titled Performance Limits.

37. *"Point of Impingement"* means any point outside the facility in the natural environment and as defined by s.2 of *O. Reg. 419/05.*

38. *"Point of Reception"* means Point of Reception as defined by *Publication NPC-205* and/or *Publication NPC-232,* as applicable.

39. *"Pre-Test Information"* means the information outlined in Section 1 of the *Source Testing Code.*

40. *"Procedure Document"* means *Ministry* Procedure titled "Procedure for Preparing an Emission Summary and Dispersion Modelling Report" dated July 2005, as amended.

41. *"Processes with Significant Environmental Aspects"* means the *Equipment* which, during regular operation or if not properly operated or maintained, may cause or are likely to cause an adverse effect.

42. *"Publication NPC-103"* means Publication NPC-103, Measurement Procedures, August 1978.

43. *"Publication NPC-205"* means the *Ministry* Publication NPC-205, "Sound Level Limits for Stationary Sources in Class 1 & 2 Areas (Urban)", October, 1995 as amended.

44. *"Publication NPC-207"* means the *Ministry* draft technical publication "Impulse Vibration in Residential Buildings", November 1983, supplementing the Model Municipal Noise Control By-Law, Final Report, August 1978, published by the *Ministry.*

45. *"Publication NPC-232"* means the *Ministry* Publication NPC-232, "Sound Level Limits for Stationary Sources in Class 3 Areas (Rural)", October, 1995 as amended.

46. *"Publication NPC-233"* means the *Ministry* Publication NPC-233, "Information to be Submitted for Approval of Stationary Sources of Sound", October, 1995 as amended.

47. *"Sensitive Receptor"* means any location where routine or normal activities occurring at reasonably expected times would experience adverse effect(s) from odour discharges from the *Facility,* including one or a combination of:

(a) private residences or public facilities where people sleep (e.g. single and multi-unit dwellings, nursing homes, hospitals, trailer parks, camping grounds, etc.),
(b) institutional facilities (e.g.: schools, churches, community centres, day care centres, recreational centres, etc.),
(c) outdoor public recreational areas (e.g.: trailer parks, play grounds, picnic areas, etc.), and
(d) other outdoor public areas where there are continuous human activities (e.g.: commercial plazas and office buildings).

48. *"Schedules"* means the following schedules attached to the *Certificate* and forming part of the *Certificate* namely:

Schedule A - Supporting Documentation
Schedule B - Stack Emission Limits
Schedule C - Specifications of *CEM System*
Schedule D - List of Polycyclic Organic Matter
Schedule E - Procedure to Calculate 10-Minute Average Concentration
Schedule F - International Toxicity Equivalence Factors

49. *"Start-up Date"* means the date when biomass or biosolids is first received in the *Facility.*

50. *"Source Testing Code"* means the Source Testing Code, Version 2, Report No. ARB-66-80, dated November 1980, prepared by the *Ministry,* as amended.

51. *"Source Testing"* means sampling and testing to measure emissions from the *Facility* as required under terms and conditions in this *Certificate* from the specified exhaust(s) under process conditions which represent a maximum operating range within the approved operating range of the *Facility,* or the maximum achievable at the times of the testing.

52. *"Supporting Documentation"* means the documents listed in Schedule A of this *Certificate* which forms part of this *Certificate.*

53. *"Toxicologist"* means a qualified professional currently active in the field of risk assessment, risk management and toxicology that has a combination of formal university education, training and experience necessary to assess the *Compound of Concern* in question.

54. *"Written Summary"* means the written summary that must be submitted annually to the *Ministry* as required by the Section titled Reporting Requirements of this *Certificate.*

You are hereby notified that this approval is issued to you subject to the terms and conditions outlined below:

TERMS AND CONDITIONS

1. GENERAL

1.1 Except as otherwise provided by this *Certificate,* the *Facility* shall be designed, developed, built, operated and maintained in accordance with the terms and conditions of this *Certificate* and in accordance with the application, the *ESDM Report,* the *Acoustic Assessment Report,* plans, specifications and *Supporting Documentation* submitted and the following *Schedules* attached hereto:

Schedule A - Supporting Documentation
Schedule B - Stack Emission Limits
Schedule C - Specifications of *CEM System*
Schedule D - List of Polycyclic Organic Matter
Schedule E - Procedure to Calculate 10-Minute Average Concentration
Schedule F - International Toxicity Equivalence Factors

1.2 The *Company* shall notify the *District Manager* in writing not later than five (5) business days after the *Start-up Date* of the *Facility.*

1.3 The *Company* shall notify the *District Manager* in writing not later than five (5) business days after the respective *Commercial Operation Date* of the first gasification train and the second gasification train.

2. OPERATIONAL FLEXIBILITY

2.1 The *Company* may make *Modifications* to the *Facility* in accordance with this *Certificate.*

2.2 Despite Condition 2.1, all *Modifications* made by the *Company* shall be within the *Operating Envelope* of the *Facility* as defined by conditions 2.3 to 2.7.

2.3 Despite Condition 2.1, the *Company* shall not make *Modifications* to the *Facility* that are outside the scope of the intended operations of the *Facility* as described in the *Description Section.*

2.4 Despite Condition 2.1, the *Company* shall not make *Modifications* to the *Facility* that result in an increase of the *Facility Production Limit* above the level specified in this *Certificate.*

2.5 Despite Condition 2.1, the *Company* shall not make *Modifications* to the *Facility* that would add any *Equipment with Specific Operational Limits.* The *Company* shall operate *Equipment with Specific Operational Limits* approved by this *Certificate* in accordance with the original *ESDM Report.*

2.6 Despite Condition 2.1, the *Company* shall only make *Modifications* to the *Facility* which comply with the *Performance Limits.*

2.7 Despite Condition 2.1, the *Company* shall not make *Modifications* to the *Facility* if the *Modifications* would be subject to the *Environmental Assessment Act.*

2.8 Condition 2.1 of this *Certificate* shall expire five (5) years from the date of this *Certificate,* unless this *Certificate* is revoked prior to this date. Upon expiry of Condition 2.1 of this *Certificate,* the *Company* shall apply for amendment to include the current *ESDM Report* and the current *Acoustic Assessment Report* in Schedule A as *Supporting Documentation* to this *Certificate.*

3. PERFORMANCE LIMITS

3.1 The *Company* shall, at all times, ensure that all *Equipment* that are a source of a *Compound of Concern* from the *Facility* are operated to comply with the following *Performance Limits:*

(a) the maximum concentration of any *Compound of Concern* at a *Point of Impingement* shall not exceed the corresponding *Ministry Point of Impingement Limit;*

(b) for any *Compound of Concern* that does not have a *Ministry Point of Impingement Limit,* the maximum concentration of any *Compound of Concern* at a *Point of Impingement* shall not be greater than a level assessed as part of the original *ESDM Report;*

(c) for any *Compound of Concern* that does not have a *Ministry Point of Impingement Limit,* the maximum concentration of any *Compound of Concern* at a *Point of Impingement* shall not be greater than the *Maximum Concentration Level Assessment* submitted to the *Ministry* and accepted by the *Air Standards Manager.*

(d) the concentrations of suspended particulate matter, mercury and dioxins and furans in the undiluted gases emitted from the stacks of the gasification trains are not greater than the emission limits specified in Schedule "B" of this *Certificate.* The concentrations of these contaminants shall be normalized to 11 percent oxygen and zero percent moisture (dry), and at a reference temperature of 25 degrees Celsius and a reference pressure of 101.3 kilopascals. The toxic equivalent concentration of dioxins and furans shall be calculated using the toxicity equivalence factors recommended by the International Scheme as set out in Schedule "F" of this *Certificate.*

(e) the maximum 10-minute average concentration of odour at the most impacted *Sensitive Receptor,* computed in accordance with Schedule "E", resulting from the operation of the *Facility,* shall not be greater than 1.0 odour unit.

3.2 The *Company* shall, no later than thirty (30) days prior to:

(a) the introduction of a new *Compound of Concern* that does not have a *Ministry Point of Impingement Limit;*

(b) an increase to the concentration at a *Point of Impingement* of a *Compound of Concern* that does not have a *Ministry Point of Impingement Limit* such that the resulting concentration at a *Point of Impingement* will be greater than the level that was reviewed as part of the original *ESDM Report;* or

(c) an increase to the concentration at a *Point of Impingement* of a *Compound of Concern* that does not have a *Ministry Point of Impingement Limit* such that the resulting concentration at a *Point of Impingement* will be greater than the corresponding *Maximum Concentration Level Assessment* previously accepted by the *Air Standards Manager;*

submit a proposed or revised *Maximum Concentration Level Assessment* for the *Compound of Concern* to the *Director* for review by the *Air Standards Manager.*

3.3 The *Company* may not use the *Maximum Concentration Level Assessment* prior to thirty (30) days from the date of an acknowledgment letter from the *Ministry* unless the *Company* receives written acceptance by the *Director* within that thirty (30) days period.

3.4 If the *Air Standards Manager* does not accept the proposed *Maximum Concentration Level Assessment,* the *Company* shall not introduce or increase the emission rate of the *Compound of Concern* without approval from the *Director.*

3.5 The *Company* shall ensure that the noise emissions from the *Facility* comply with the limits set in *Publication NPC-205.*

4. DOCUMENTATION REQUIREMENTS

4.1 The *Company* shall, at all times, maintain documentation that describes the current operations of the *Facility,* including but not limited to:

(a) a current *ESDM Report* that demonstrates compliance with the *Performance Limits* for the *Facility* regarding all *Compounds of Concern;*

(b) a current *Acoustic Assessment Report* that demonstrates compliance with the *Performance Limits* for the *Facility* regarding noise emissions;

(c) an up-to-date *Log* that describes each *Modification* to the *Facility;* and

(d) a record of the changes to the *ESDM Report* and *Acoustic Assessment Report* that documents how each *Modification* is in compliance with the *Performance Limits.*

4.2 The *Company* shall, during regular business hours, make the current *Emission Summary Table* and *Acoustic Assessment Summary Table,* and the table comparing the predicted or, once when they are available, the latest source test results of the contaminants with the stack emission limits in Schedule "B" of this *Certificate* available for inspection at the *Facility* by any interested member of the public.

5. REPORTING REQUIREMENTS

5.1 The *Company* shall provide the *District Manager* and the *Director* no later than March 31 of each year, a *Written Summary* of activities undertaken in the previous calendar year that shall include the following:

(a) a signed statement from a director or officer of the *Company* with charge, management or control of the *Facility,* that the *Facility* was in compliance with the *Performance Limits;*

(b) a summary of each *Modification* that took place in the previous calendar year and resulted in a change in the previously calculated concentration at the *Point of Impingement* for any *Compound of Concern* or resulted in a change in the sound levels reported in the *Acoustic Assessment Summary Table* at any *Point of Reception;*

(c) a list of each *Compound of Concern* submitted to the *Air Standards Manager* for review in the previous calendar year;

(d) a review of any changes to a *Ministry Point of Impingement Limit* undertaken in the previous calendar year that affect a *Compound of Concern* emitted from the *Facility;*

(e) a tabulated summary of the changes in the emission rate of any *Compound of Concern* and the resultant increase or decrease in the *Point of Impingement* concentration reported in the *ESDM Report* over the previous calendar year; and

(f) the *Emission Summary Table, Acoustic Assessment Summary Table* and the table of comparison between the latest source test results of the contaminants with the stack emission limits in Schedule "B" for the *Facility* as of December 31 from the previous calendar year.

6. OPERATION AND MAINTENANCE

6.1 The *Company* shall prepare prior to and implement starting from the *Start-up Date* of the *Facility,* operating procedures and maintenance programs documented in the form of a *Manual* and updated, as necessary, for all *Processes with Significant Environmental Aspects.* The *Company* shall ensure that all *Processes with Significant Environmental Aspects* are operated and maintained at all times in accordance with this *Certificate,* and the most updated operating procedures and maintenance programs. The *Manual* shall specify as a minimum:

(a) a start-up and commissioning protocol, to specify the procedures in this period such that the *Facility* is started up such that the environmental impacts to the *Sensitive Receptors* are minimized;

(b) routine operating procedures and maintenance programs in accordance with good engineering practices and as recommended by the *Equipment* suppliers;

(c) frequency of inspections and scheduled preventative maintenance of the *Equipment;*

(d) the parameters to be monitored and the frequency of their monitoring for the *Biofilter* to ensure the proper operation of the *Biofilter,* and the specifications and calibration requirements of the measuring devices used for the monitoring of the parameters;

(e) inspection program on the proper operation of the baghouses and maintenance program on replacement of filter bags of the baghouses;

(f) procedures to prevent upset conditions, including spill clean-up procedures;

(g) the *Odour Management Plan,* periodically e.g. annually reviewed and updated as necessary, identifying elements of operation of the *Facility* that have a potential to release odour including fugitive odour and outlining the operational controls, monitoring, measurement and corrective actions, and communication and management reviews required to achieve the objective of managing odour associated with the operation of the *Facility* in order to prevent or mitigate any odour impacts on the *Sensitive Receptors.* The plan shall also include incoming materials unloading and storage procedures and a contingency plan to deal with the storage of incoming materials when the *Facility* experiences planned or emergency shut down;

(h) the *Dust Management Plan,* periodically e.g. annually reviewed and updated as necessary, identifying fugitive dust emissions from the operation of the *Facility* and outlining the physical and procedural controls such as policies and standard operating procedures required in order to prevent or mitigate fugitive dust emissions from the operation of the *Facility;*

(i) procedures for all record keeping activities relating to the operation and maintenance programs.

6.2 The *Company* shall keep all doors in the biomass and biosolids unloading and storage areas of the building fully closed at all times, except when being used for necessary personnel and/or vehicle entrance and exit.

6.3 The *Company* shall ensure that all the areas in the building dedicated to biomass and biosolids receipt, unloading, pre-processing (e.g. screening) and storage are operated under negative pressure. This negative pressure has to be monitored by negative pressure monitors and their settings adjusted accordingly.

6.4 The *Company* shall, as a minimum, monitor and record the following physical parameters of the *Biofilter,* at frequency stated below or as recommended by the *Biofilter* supplier:

(a) air flow through the bed, continuously;
(b) differential pressure across media, continuously;
(c) inlet air temperature (after humidification scrubber), continuously;
(d) process air relative humidity (after humidification scrubber), continuously; and
(e) flow rate of both the humidification scrubber re-circulation water and the media irrigation water, daily.

7. COMPLAINTS RECORDING PROCEDURE

7.1 If at any time, the *Company* receives any environmental complaints from the public regarding the operation of the *Equipment* approved by this *Certificate,* the *Company* shall respond to these complaints according to the procedures specified in the Provisional Certificate of Approval (Waste Disposal Site) issued to the *Company* for the *Facility,* as amended.

8. RECORD KEEPING REQUIREMENTS

8.1 Any information requested by the *Ministry* concerning the *Facility* and its operation under this *Certificate,* including, but not limited to, any records required to be kept by this *Certificate,* shall be provided to the *Ministry,* upon request**,** in a timely manner.

8.2 The *Company* shall retain, for a minimum of seven (7) years from the date of their creation, except as noted below, all reports, records and information described in this *Certificate* and shall include but not be limited to:

(a) the current *ESDM Report;*

(b) the *Acoustic Assessment Report;*

(c) supporting information used in the emission rate calculations performed in the *ESDM Report* and *Acoustic Assessment Report* to document compliance with the *Performance Limits* (superseded information must be retained for a period of three (3) years after *Modification);*

(d) the *Log* that describes each *Modification* to the *Facility;*

(e) the *Written Summaries* provided to the *Ministry;*

(f) the operating procedures and maintenance programs, including records on the maintenance, repair and inspection of the *Equipment* related to all *Processes with Significant Environmental Aspects;*

(g) all monitoring results recorded by the *CEM System, Source Testing,* and acoustic audit measurements;

(h) all monitoring results on the operation and performance of the *Biofilter;*

(i) the complaints recording procedure, including records related to all environmental complaints made by the public as required by the section titled Complaints Recording Procedure of this *Certificate.*

9. REVOCATION OF PREVIOUS CERTIFICATES OF APPROVAL (AIR & NOISE)

9.1 This *Certificate* replaces and revokes all Section 9 Certificates of Approval issued to the *Facility* and dated prior to the date of this *Certificate.*

10. EMISSION MONITORING REQUIREMENTS

10.1 The *Company* shall install and maintain operational a *CEM System,* before the date when biosolids or biomass is first fed to the fluidized bed reactor of the first gasification train, to continuously monitor and record the temperature, opacity, and concentrations of nitrogen oxides, carbon monoxide, hydrogen chloride and oxygen. The temperature monitors, one (1) for each gasification train, shall be installed in the staged combustion air chambers of the fluidized bed reactors. The monitors for opacity, nitrogen oxides, carbon monoxide, hydrogen chloride and oxygen shall be installed to continuously monitor and record the concentrations of these parameters in the undiluted flue gases leaving the gasification train stacks. The locations and specifications of the *CEM System* are outlined in Schedule "C".

10.2 The *Company* shall, within one (1) year after the date when biosolids or biomass is first fed to the fluidized bed reactor of the first gasification train, submit a report to the *Director* and the *District Manager* on the evaluation of performance of the continuous monitor for hydrogen chloride installed in the *Facility,* including but not limited to its monitored results as compared with the results obtained by the *Source Testing.* If the monitored results were found to be unreliable or faulty, the *Company* shall include in the report an alternative, for approval by the *Director* and the *District Manager,* such that the concentrations of hydrogen chloride in the undiluted flue gases leaving the gasification train stacks can be continuously monitored and recorded.

10.3 The *Company* shall perform *Source Testing* to determine the rates of air emissions from the following sources in the *Facility:*

<u>*Biofilter:*</u>

(a) once during Phase 1 of the start-up and commissioning phase of the *Facility*and once during Phase 3 of the start-up and commissioning phase of the *Facility,*the rate of odour loading to the *Biofilter*inlet before the humidification chamber and from the *Biofilter*exhaust. The times of these tests have to be agreed or as directed by the *District Manager*or *Manager;*

(b) within one (1) year after the *Start-up Date*of the *Facility,*in a time period either proposed by the *Company*and agreed by the *District Manager*or directed by the *District Manager*or *Manager,*the rate of odour loading to the *Biofilter*inlet before the humidification chamber and from the *Biofilter*exhaust, under the following operational scenarios of the *Facility:*

> (i) Normal Operation Case, when the first gasification train is operating at the approved maximum combined processing rates of biomass and biosolids with the associated maximum quantities of biomass and biosolids under this situation are stored in the *Facility,*or at an operational scenario of the gasification train and *Facility*storage agreed or as directed by the *District Manager*or the *Manager,*
>
> (ii) Curtailment Case, when the fluidized bed reactor of the first gasification train is down for maintenance with the maximum quantities of biomass and biosolids under this situation are still stored in the *Facility,*or at a material storage scenario agreed or as directed by the *District Manager*or the *Manager;*

(c) within three (3) months after the *Commercial Operation Date*of the second gasification train, the rate of odour loading to the *Biofilter*inlet before the humidification chamber and from the *Biofilter*exhaust, under the following operational scenario of the *Facility:*

> (i) when both gasification trains are operating at the approved maximum combined processing rates of biomass and biosolids with the associated maximum quantities of biomass and biosolids under this situation are stored in the *Facility,*or at an operational scenario of the two (2) gasification trains and *Facility*storage agreed or as directed by the *District Manager*or the *Manager;*

<u>Gasification Trains:</u>

(d) within six (6) months after the date biosolids or biomass is first fed to the first gasification train, the rates of emissions of suspended particulate matter, hydrogen chloride, mercury, dioxins and furans, acrolein, bis(2-ethylhyxy)phthalate, chloroform, sulphur dioxide, formaldehyde, nickel and polycyclic organic matter listed in Schedule "D" in the undiluted flue gas in the first gasification train stack, when the fluidized bed reactor is fed with biomass and biosolids at their maximum combined approved processing rates or maximum achievable rates at the time of testing, or at the processing rates of biosolids and biomass in the fluidized bed reactor either proposed by the *Company*and agreed by the *District Manager*or directed by the *District Manager*or *Manager;*

(e) within six (6) months after the *Commercial Operation Date*of the second gasification train, the rates of emissions of suspended particulate matter, hydrogen chloride, mercury, dioxins and furans, acrolein, bis(2-ethylhyxy)phthalate, chloroform, sulphur dioxide, formaldehyde, nickel and polycyclic organic matter listed in Schedule "D" in the undiluted flue gas in the second gasification train stack, when the fluidized bed reactor is fed with biomass and biosolids at their maximum combined approved processing rates or maximum achievable rates at the time of testing, or at the processing rates of biosolids and biomass in the fluidized bed reactor either proposed by the *Company*and agreed by the *District Manager*or directed by the *District Manager*or *Manager.*

10.4 The *Company*shall submit to the *Manager,*not later than three (3) months prior to the *Start-up Date*of the *Facility,*two (2) test protocols, one (1) for the testing of the *Biofilter*and one (1) for the testing of the first gasification train, each including the *Pre-Test Information*for the *Source Testing*of the *Biofilter*or the first gasification train required by the *Source Testing Code.* The *Company*shall finalize the test protocols in consultation with the *Manager.* The *Company*shall also submit to the *Manager,*not later than three (3) months prior to the *Commercial Operation Date*of the second gasification train, a test protocol, including the *Pre-Test Information*for the *Source Testing*of the second gasification train required by the *Source Testing Code.* The *Company*shall finalize this test protocol in consultation with the *Manager.*

10.5 The *Company*shall, after the *Manager*has accepted the test protocols, conduct the *Source Testing*in accordance with the timing in Condition 10.3 above.

10.6 The *Company*shall notify the *Director,*the *District Manager*and the *Manager*in writing of the location, date and time of any impending *Source Testing*required by this *Certificate,*at least fifteen (15) business days prior to the *Source Testing.*

10.7 The *Company*shall, whenever a test under the *Source Testing*is completed, prepare and submit a report on the results of the test under the *Source Testing*to the *Director,*the *District Manager*and the *Manager*within two (2) months after completing the test if the *Source Testing*is conducted on the *Biofilter,*and within four (4) months after completing the test if the *Source Testing*is conducted on the gasification trains. The report shall be in the format described in the *Source Testing Code,*and shall include the following:

(a) an executive summary,

(b) weather conditions at the time of the test, for example ambient temperature, relative humidity, wind direction and speed,

(c) all operating conditions of the *Facility*at the time of the test, for example, the quantities of biomass and biosolids stored in the *Facility,*the processing rates of biomass and biosolids in the fluidized bed reactor(s), the quantity of electricity generated and fed to the grid, the operating conditions of each equipment in the air pollution control train,

(d) all records of the *CEM System*obtained at the time of the test;

(e) date and time when the test under the *Source Testing*was conducted, and the results obtained from the test, together with a comparison of the results obtained in this test with the emission data either contained in the *ESDM Report*or previous tests on the same source of emission;

(f) the results of dispersion calculations, using the results obtained in the test under the *Source Testing,*indicating the maximum 1-hour and/or 24-hour average concentrations for the contaminants other than odour, as determined according to the contaminant in consideration, at the *Point of Impingement.* For odour, the dispersion calculations have to be in accordance with Schedule "E".

10.8 If any of the *Source Testing*results obtained is higher than the emission rate contained in the most updated *ESDM Report,*the *ESDM Report*must be updated to reflect the higher emission rate(s). The *Company*shall make available the updated *ESDM Report*available for review by staff of the *Ministry*upon request. The updated *Emission Summary Table*from the updated *ESDM Report*shall also be submitted with the *Source Testing*report. If the subject contaminant is one of the contaminants in Schedule "B", this higher emission rate has also to be reported to the *Ministry*and its comparison with the stack emission limit in Schedule "B" at the time of submission of the *Source Testing*report.

10.9 The *Director*may not accept the results of the *Source Testing*if:

(a) consultation and acceptance of the *Manager*did not take place, or

(b) the *Source Testing Code*or the requirements of the *Manager,*either during the pre-test consultation or during witnessing of the *Source Testing,*were not followed, or

(c) the *Company*did not notify the *Director,*the *District Manager*or the *Manager*of the upcoming *Source Testing,*or

(d) the *Company*failed to provide a report on the *Source Testing.*

10.10 If the *Director*does not accept the results of the *Source Testing,*the *Director*may require the *Company*to repeat *Source Testing.*

10.11 The *Company*shall perform subsequent annual *Source Testing*to determine the rate of odour loading to the *Biofilter*inlet and the rate of emission of odour from the *Biofilter*exhaust in accordance with Condition No. 10.3(b)(i), and the rates of emissions of mercury, dioxins and furans, acrolein, bis(2-ethylhyxy)phthalate, chloroform, sulphur dioxide, formaldehyde, nickel and polycyclic organic matter listed in Schedule "D" from the undiluted gas in the first gasification train stack in accordance with the operational scenario specified in Condition No. 10.3(d), and Condition No. 10.3(e) if the second gasification train is installed and in operation, once during each year of operation of the *Facility.*

10.12 The *District Manager* may, based on the results of the *Source Testing,* temporarily require an increase in frequency of *Source Testing* from annually to quarterly.

10.13 The *Company* shall, not later than three (3) months before the *Start-up Date* of the *Facility,* submit to the *District Manager* for approval a continuous ambient air monitoring program for the *Facility.* The *Company* shall, upon approval by the *District Manager,* implement the program before the *Start-up Date* of the *Facility.*

10.14 (1) The *Company* shall carry out acoustic audit measurements on the actual noise emissions due to the operation of the *Facility,* in accordance with the measurement procedures in *Publication NPC-103.*

(2) The *Company* shall submit an acoustic audit report, prepared by an *Independent Acoustic Consultant,* in accordance with *Publication NPC-233,* to the *District Manager* and the *Director* not later than six (6) months after *Commercial Operation Date* of the first gasification train and not later than six (6) months after the *Commercial Operation Date* of the second gasification train.

(3) The *Director* may not accept the results of the acoustic audit if the requirements of *Publication NPC-233* were not followed.

(4) If the *Director* does not accept the results of the acoustic audit the *Director* may:

(a) require the *Company* to repeat the acoustic audit, and/or

(b) in accordance with the *EPA,* impose additional conditions to the *Company's Certificate.*

(5) If an acoustic audit report indicates that the *Facility* is not in compliance with the noise limits stated in *Publication NPC-205,* then the *Company* shall submit an application to amend their current *Certificate,* such that it includes a Noise Abatement Action Plan.

The Noise Abatement Action Plan shall include a detailed timetable of scheduled mitigating measures, with the objective to ensure that the noise emissions from the *Facility* comply with limits in *Publication NPC-205.* The Noise Abatement Action Plan shall also be based upon the objective to complete the implementation of the required mitigating measures by a date not exceeding twelve (12) months after the date approval of the application for the Noise Abatement Action Plan contemplated in this section is granted to the *Company.*

If applicable, the new application must be sent to the *District Manager* and the *Director,* by a date not exceeding twelve (12) months, after the *Commercial Operation Date* of the applicable gasification train(s).

SCHEDULE "A"

Supporting Documentation

(a) Application dated October 25, 2007, signed by Wilson Nolan and submitted by the C*ompany* for a Certificate of Approval (Air & Noise);

(b) Emission Summary and Dispersion Modelling Report (ESDM Report), dated September 2007;

(c) A letter served as addendum to the ESDM Report, dated October 31, 2007 and signed by Gordon Reusing, P.Eng., Conestoga-Rovers & Associates;

(d) Acoustic Assessment Report prepared by Conestoga-Rovers & Associates and dated January 2008;

(e) Additional information contained in a letter dated February 27, 2008 and signed by Gordon Reusing, P.Eng., Conestoga-Rovers & Associates;

(f) Additional information contained in the attachment of an email sent from Dana Arkilander, Conestoger-Rovers & Associates on February 28, 2008 to Rudolf Wan, P.Eng. of the *Ministry;*

(g) A letter dated April 16, 2008 and signed by Gordon Reusing, P.Eng., Conestoga-Rovers & Associates, with the revised ESDM Report dated April 2008 attached.

(h) A letter dated April 24, 2008 and signed by Gordon Reusing, P.Eng., Conestoga-Rovers & Associates, to serve as an addendum to the revised ESDM Report dated April 2008.

(i) An email sent from Dana Arkilander of Conestoga-Rovers & Associates to Rudolf Wan of the *Ministry*on April 25, 2008, with attachments to serve as addendum to the letter dated April 24, 2008 and signed by Gordon Reusing, P.Eng., Conestoga-Rovers & Associates, described above.

SCHEDULE "B"

Stack Emission Limits

Parameter	Stack Emission Limit	Comment
Suspended particulate matter	50 mg/Rm3	Calculated as the arithmetic average of 3 stack tests
Mercury	70 ug/Rm3	Calculated as the arithmetic average of 3 stack tests
Dioxins and Furans	80 pg I-TEQ/Rm3	Calculated as the arithmetic average of 3 stack tests

Notes:
(1) mg/Rm3 means milligrams per reference cubic metre.
(2) ug/Rm3 means micrograms per reference cubic metre.
(3) pg I-TEQ/Rm3 means picograms of toxicity equivalents (calculated using the toxicity equivalence factors recommended by the North Atlantic Treaty Organization's Committee on Challenges to Modern Society (NATO/CCMS) in 1989 and adopted by Canada in 1990) to 2,3,7,8 tetrachlorodibenzo-p-dioxin per reference cubic metre.

SCHEDULE "C"

Specifications of *CEM System*

C.1 CONTINUOUS TEMPERATURE MONITOR AND DATA RECORDER

PARAMETER: Temperature

INSTALLATION:
The Continuous Temperature Monitor shall be installed at an appropriate location where the measurements give the actual operating temperature of the staged combustion air chambers of the fluidized bed reactors.

PERFORMANCE:
The Continuous Temperature Monitor shall meet the following minimum performance specifications for the following parameters:

	PARAMETERS	SPECIFICATION
1	Type:	shielded "K" type thermocouple or equivalent
2	Accuracy:	± 1.5 percent of the minimum gas temperature

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor without a significant loss of accuracy and with a time resolution of 5 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time, on a monthly basis, when the fluidized bed reactor is in operation.

C.2 CONTINUOUS NITROGEN OXIDES MONITOR AND DATA RECORDER

PARAMETER: Nitrogen Oxides

INSTALLATION:
The Continuous Nitrogen Oxides Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of nitrogen oxides in the gases leaving the gasification train stacks and shall meet the following installation specifications.

	PARAMETERS	SPECIFICATION
1.	Analyzer Operating Range (ppm):	0 to 200
2.	Calibration Gas Ports:	close to the sample point

PERFORMANCE:
The Continuous Nitrogen Oxides Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	SPECIFICATION
1. Span Value (nearest ppm equivalent):	2 times the average normal concentration of the source
2. Relative Accuracy:	≤ 10 percent of the mean value of the reference method test data
3. Calibration Error:	≤ 2 percent of actual concentration
4. System Bias:	≤ 4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check:	all system components checked
6. Zero Calibration Drift (24-hour):	≤ 2.5 percent of span value
7. Span Calibration Drift (24-hour):	≤ 2.5 percent of span value
8. Response Time (90 percent response to a step change):	≤ 200 seconds
9. Operational Test Period:	≥ 168 hours without corrective maintenance

CALIBRATION:
Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter.

C.3 CONTINUOUS HYDROGEN CHLORIDE MONITOR AND DATA RECORDER

PARAMETER: Hydrogen Chloride

INSTALLATION:
The Continuous Hydrogen Chloride Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of hydrogen chloride in the gases leaving the gasification train stacks and shall meet the following installation specifications.

	PARAMETERS	SPECIFICATION
1.	Range (parts per million, ppm):	0 to 36
2.	Calibration Gas Ports:	close to the sample point

PERFORMANCE:
The Continuous Hydrogen Chloride Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	SPECIFICATION
1. Span Value (nearest ppm equivalent):	2 times the average normal concentration of the source
2. Relative Accuracy:	≤ 20 percent of the mean value of the reference method test data or ± 5 ppm whichever is greater
3. Calibration Error:	≤ 2 percent of actual concentration
4. System Bias:	≤ 4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check:	all system components checked
6. Zero Calibration Drift (24-hour):	≤ 5 percent of span value
7. Span Calibration Drift (24-hour):	≤ 5 percent of span value
8. Response Time (90 percent response to a step change):	≤ 200 seconds
9. Operational Test Period:	≥ 168 hours without corrective maintenance

CALIBRATION:
The monitor shall be calibrated daily at the sample point, to ensure that it meets the drift limits specified above, during the periods of the operation of the gasification trains. The results of all calibrations shall be recorded at the time of calibration.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 5 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter.

C.4 CONTINUOUS CARBON MONOXIDE MONITOR AND DATA RECORDER

PARAMETER: Carbon Monoxide

INSTALLATION:
The Continuous Carbon Monoxide Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of carbon monoxide in the undiluted gases leaving the gasification train stacks and shall meet the following installation specifications.

	PARAMETERS	SPECIFICATION
1.	Range (percent):	0 to 0.2
2.	Calibration Gas Ports:	close to the sample point

PERFORMANCE:
The Continuous Carbon Monoxide Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	SPECIFICATION
1. Span Value (nearest ppm equivalent):	2 times the average normal concentration of the source
2. Relative Accuracy:	≤ 10 percent of the mean value of the reference method test data or ± 5 ppm whichever is greater
3. Calibration Error:	≤ 2 percent of actual concentration
4. System Bias:	≤ 4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check:	all system components checked
6. Zero Calibration Drift (24-hour):	≤ 5 percent of span value
7. Span Calibration Drift (24-hour):	≤ 5 percent of span value
8. Response Time (90 percent response to a step change):	≤ 90 seconds
9. Operational Test Period:	≥ 168 hours without corrective maintenance

CALIBRATION:
Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter.

C.5 CONTINUOUS OPACITY MONITOR AND DATA RECORDER

PARAMETER: Opacity

INSTALLATION:
The Continuous Opacity Monitor shall be installed at an accessible location where the measurements are representative of the actual opacity in the gasification train exhausts and shall meet the following design and installation specifications.

	PARAMETERS	SPECIFICATION
1.	Wavelength at Peak Spectral Response (nanometres, nm):	500 - 600
2.	Wavelength at Mean Spectral Response (nm):	500 - 600
3.	Detector Angle of View:	≤ 5 degrees
4.	Angle of Projection:	≤ 5 degrees
5.	Range (percent of opacity):	0 -100

PERFORMANCE:
The Continuous Opacity Monitor shall meet the following minimum performance specifications for the following parameters:

	PARAMETERS	SPECIFICATION
1	Span Value (percent opacity):	2 times the average normal opacity of the source
2	Calibration Error:	≤ 3 percent opacity
3	Attenuator Calibration:	≤ 2 percent opacity
4	Response Time (95% response to a step change):	≤ 10 seconds
5	Schedule for Zero and Calibration Checks:	daily minimum
6	Procedure for Zero and Calibration Checks:	all system components checked
7	Zero Calibration Drift (24-hour):	≤ 2% opacity
8	Span Calibration Drift (24-hour):	≤ 2% opacity
9	Conditioning Test Period:	≥ 168 hours without corrective maintenance
10	Operational Test Period :	≥ 168 hours without corrective maintenance

CALIBRATION:
The monitor shall be calibrated daily, to ensure that it meets the drift limits specified above, during the periods of operation of the gasification trains. The results of all calibrations shall be recorded at the time of calibration.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor without a significant loss of accuracy and with a time resolution of 5 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time, on a monthly basis, when the gasification train is in operation.

C.6 CONTINUOUS OXYGEN MONITOR AND DATA RECORDER

PARAMETER: Oxygen

INSTALLATION:
The Continuous Oxygen Monitor shall be installed at an accessible location where the measurements are representative of the actual concentration of oxygen in the undiluted gases leaving the gasification train stacks and shall meet the following installation specifications.

	PARAMETERS	SPECIFICATION
1.	Range (percent):	0 - 20 or 0 - 25
2.	Calibration Gas Ports:	close to the sample point

PERFORMANCE:
The Continuous Oxygen Monitor shall meet the following minimum performance specifications for the following parameters.

PARAMETERS	SPECIFICATION
1. Span Value (percentage):	2 times the average normal concentration of the source
2. Relative Accuracy:	≤ 10 percent of the mean value of the reference method test data
3. Calibration Error:	0.25 percent O2
4. System Bias:	≤ 4 percent of the mean value of the reference method test data
5. Procedure for Zero and Span Calibration Check:	all system components checked
6. Zero Calibration Drift (24-hour):	≤ 0.5 percent O2
7. Span Calibration Drift (24-hour):	≤ 0.5 percent O2
8. Response Time (90 percent response to a step change):	≤ 90 seconds
9. Operational Test Period:	≥ 168 hours without corrective maintenance

CALIBRATION:
Daily calibration drift checks on the monitor shall be performed and recorded in accordance with the requirements of Report EPS 1/PG/7.

DATA RECORDER:
The data recorder must be capable of registering continuously the measurement of the monitor with an accuracy of 0.5 percent of a full scale reading or better and with a time resolution of 2 minutes or better.

RELIABILITY:
The monitor shall be operated and maintained so that accurate data is obtained during a minimum of 90 percent of the time for each calendar quarter during the first full year of operation, and 95 percent, thereafter.

SCHEDULE "D"

List of Polycyclic Organic Matter

Polycyclic Organic Matter:

Acenaphthylene
Acenaphthene
Anthracene
Benzo(a)anthracene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)fluorene
Benzo(b)fluorene
Benzo(g,h,i)perylene
Benzo(a)pyrene
Benzo(e)pyrene
2-Chloronaphthalene
Chrysene
Coronene
Dibenzo(a,c)anthracene
9,10-Dimethylanthracene
7,12-Dimethylbenzo(a)anthracene
Fluoranthene
Fluorene
Indeno(1,2,3-c,d)pyrene
2-Methylanthracene
3-Methylcholanthrene
1-Methylnaphthalene

2-Methylnaphthalene
1-Methylphenanthrene
9-Methylphenanthrene
Naphthalene
Perylene
Phenanthrene
Picene
Pyrene
Tetralin
Triphenylene

SCHEDULE "E"
Procedure to Calculate 10-Minute Average Concentration

(a) Calculate and record one-hour average concentrations of odour at the *Point of Impingement* and at the most impacted *Sensitive Receptor,* employing the *AERMOD* atmospheric dispersion model or with another atmospheric dispersion model acceptable to the *Director* that employs at least five (5) years of hourly local meteorological data and that can provide results reported as individual one-hour average odour concentrations;

(b) Convert and record each of the one-hour average concentrations predicted over the five (5) years of hourly local meteorological data at the *Point of Impingement* and at the most impacted *Sensitive Receptor* to 10-minute average concentrations using the One-hour Average to 10-Minute Average Conversion described below; and

(c) Record and present the 10-Minute Average concentrations predicted to occur over a five (5) year period at the *Point of Impingement* and at the most impacted *Sensitive Receptor* in a histogram. The histogram shall identify all predicted 10-minute average odour concentration occurrences in terms of frequency, identifying the number of occurrences over the entire range of predicted odour concentration in increments of not more than 1/10 of one odour unit. The maximum 10-minute average concentration of odour at the *Sensitive Receptor* will be considered to be the maximum odour concentration corresponding to 99.5% of the time in the 5 year modelling period at the most impacted *Sensitive Receptor,* as determined in accordance with section 6.6 of the ministry's document titled "Air Dispersion Modelling Guideline for Ontario" dated July 2005.

One-hour Average To 10-minute Average Conversion

Use the following formula to convert and record one-hour average concentrations predicted by the *AERMOD* atmospheric dispersion model to 10-minute average concentrations:

X(10min) = X(60min) x 1.65

where X(10min) = 10-minute average concentration
X(60min) = one-hour average concentration

SCHEDULE "F"

INTERNATIONAL TOXICITY EQUIVALENCE FACTORS

Dioxin/Furan Isomers of Concern	International Toxicity Equivalence Factors (I-TEF's)
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	0.5
1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin	0.1
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	0.01
1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin	0.001
2,3,7,8-Tetrachlorodibenzofuran	0.1
2,3,4,7,8-Pentachlorodibenzofuran	0.5
1,2,3,7,8-Pentachlorodibenzofuran	0.05
1,2,3,4,7,8-Hexachlorodibenzofuran	0.1
1,2,3,6,7,8-Hexachlorodibenzofuran	0.1
1,2,3,7,8,9-Hexachlorodibenzofuran	0.1
2,3,4,6,7,8-Hexachlorodibenzofuran	0.1
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.01
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.01
1,2,3,4,6,7,8,9-Octachlorodibenzofuran	0.001

The reasons for the imposition of these terms and conditions are as follows:

1. GENERAL

Condition No. 1.1 is included to require the *Certificate* holder to build, operate and maintain the *Facility* in accordance with the *Supporting Documentation* considered by the *Director* in issuing this *Certificate.* Conditions No. 1.2 and 1.3 are included to assist the *Ministry* to determine the site's compliance with the *EPA,* the regulations and this *Certificate.*

2. OPERATIONAL FLEXIBILITY AND PERFORMANCE LIMITS

Conditions No. 2 and 3 are included to limit *Modifications* and define the operating envelope permitted by this *Certificate.* The holder of the *Certificate* is approved for operational flexibility for the *Facility* that is consistent with the description of the operations included with the application up to the *Facility Production Limit.* In return for the operational flexibility the *Certificate* places performance based limits that cannot be exceeded under the terms of this *Certificate,* to provide the minimum performance requirements considered necessary to prevent an adverse effect resulting from the operation of the *Facility. Certificate* holders will still have to obtain other relevant approvals required to operate the *Facility,* including requirements under other environmental legislation such as the *Environmental Assessment Act.*

3. DOCUMENTATION REQUIREMENTS

Condition No. 4 is included to require the *Company* to maintain ongoing documentation that demonstrates compliance with the *Performance Limits* of this *Certificate* and allows the *Ministry* to monitor on-going compliance with these *Performance Limits.* The *Company* is required to have an up to date *ESDM Report* and *Acoustic Assessment Report* that describe the *Facility* at all times and make the *Emission Summary Table* and *Acoustic Assessment Summary Table* from these reports available to the public on an ongoing basis in order to maintain public communication with regard to the emissions from the *Facility.*

4. REPORTING REQUIREMENTS

Condition No. 5 is included to require the *Company* to provide a yearly *Written Summary* to the *Ministry.*

5. OPERATION AND MAINTENANCE

Condition No. 6 is included to require the *Company* to properly operate and maintain the *Processes with Significant Environmental Aspects* to minimize the impact to the environment from these processes, and to emphasize that the *Facility* must be maintained and operated according to a procedure that will result in compliance with the *EPA,* the regulations and this *Certificate.*

6. COMPLAINTS RECORDING PROCEDURE

Condition No. 7 is included to require the *Company* to respond to any environmental complaints regarding the operation of the *Equipment,* according to a procedure that includes methods for preventing recurrence of similar incidents and a requirement to prepare and retain a written report.

7. RECORD KEEPING REQUIREMENTS

Condition No. 8 is included to require the *Company* to retain all documentation related to this *Certificate* and provide access to *Ministry* staff, upon request, so that the *Ministry* can determine if a more detailed review of compliance with the *Performance Limits* is necessary.

8. REVOCATION OF PREVIOUS CERTIFICATES OF APPROVAL (Air and Noise)

Condition No. 9 is included to confirm that this *Certificate* replaces all Section 9 Certificate(s) of Approval that have been previously issued for this *Facility.*

9. EMISSION MONITORING REQUIREMENTS

Condition No. 10 is included to require the *Company* to gather accurate information so that the environmental impact and subsequent compliance with the *EPA,* the regulations and this *Certificate* can be verified.

In accordance with Section 139 of the Environmental Protection Act, R.S.O. 1990, Chapter E-19, as amended, you may by written notice served upon me and the Environmental Review Tribunal within 15 days after receipt of this Notice, require a hearing by the Tribunal. Section 142 of the Environmental Protection Act, provides that the Notice requiring the hearing shall state:

1. The portions of the approval or each term or condition in the approval in respect of which the hearing is required, and;
2. The grounds on which you intend to rely at the hearing in relation to each portion appealed.

The Notice should also include:

3. The name of the appellant;
4. The address of the appellant;
5. The Certificate of Approval number;
6. The date of the Certificate of Approval;
7. The name of the Director;
8. The municipality within which the works are located;

And the Notice should be signed and dated by the appellant.

This Notice must be served upon:

CONTENT COPY OF ORIGINAL

The Secretary* Environmental Review Tribunal 2300 Yonge St., Suite 1700 P.O. Box 2382 Toronto, Ontario M4P 1E4	AND	The Director Section 9, *Environmental Protection Act* Ministry of the Environment 2 St. Clair Avenue West, Floor 12A Toronto, Ontario M4V 1L5

*** Further information on the Environmental Review Tribunal's requirements for an appeal can be obtained directly from the Tribunal at: Tel: (416) 314-4600, Fax: (416) 314-4506 or www.ert.gov.on.ca**

The above noted works are approved under Section 9 of the Environmental Protection Act.

DATED AT TORONTO this 22nd day of September, 2008

Ian Greason, P.Eng.
Director
Section 9, *Environmental Protection Act*

RW/
c: District Manager, MOE Hamilton District Office
Gordon Reusing, P.Eng., Conestoga-Rovers & Associates

APPENDIX E-7

Greater Vancouver Regional District Energy-From-Waste Facility, Burnaby, BC

Greater Vancouver

Regional Solid Waste Management Plan

July, 1995

APPENDIX D

LONG TERM MONITORING REQUIREMENTS FOR THE BURNABY INCINERATOR

The Technical Review Committee, chaired by the Ministry of Environment, Lands and Parks, is responsible for monitoring the performance of the Burnaby Incinerator and recommending any changes to the Ministry. The membership of the committee includes the BC Ministry of Environment, Environment Canada, the Metropolitan Board of Health and the GVRD. The Source Monitoring Subcommittee of the Technical Review Committee was established to assess the air emission monitoring program for the Burnaby Incinerator. The assessment is provided in the document titled "GVRD Municipal Incinerator - Review of Source Monitoring", dated January 18, 1994. It focuses on the reconciliation of current source monitoring requirements with the BC MSW Criteria in the context of comparable North American standards and makes recommendations for long term source emission objectives and source monitoring program.

The following long term monitoring requirements will be applied at the Burnaby Incinerator. These criteria were developed through the aforementioned process and a follow-up report prepared by the District titled "Burnaby Incinerator - Review of Emission Criteria", dated June 3, 1994. This report clarifies the capabilities of the emission control system, documents the handling of regulatory issues in different jurisdictions and provides details of the environmental programs conducted at the incinerator during the first six years of operation.

1.0 Air Discharge Limits and Monitoring Methods

Where applicable, all contaminant concentrations are stated at standard conditions of 293 K, 101.3 kilopascals (1 atmosphere), corrected to 11 % oxygen and dry basis unless otherwise noted.

Discharge specifications apply to each incinerator unit separately. A continuous time-shared analyzing system is used for monitoring emissions from all three incineration units.

1.1 Opacity

Opacity shall not exceed 5% based on 1-hour averaging of continuous monitoring.

1.2 Particulate Matter

Particulate matter from each incinerator stack shall not exceed 20 mg/m^3 based on manual stack testing methods approved by the Regional Waste Manager.

1.3 Carbon Monoxide (CO)

Carbon monoxide emissions shall not exceed 55 mg/m^3 for steady state incinerator operation based on a 4-hour rolling average of continuous monitoring.

1.4 Sulphur Dioxide (SO_2)

Sulphur dioxide emissions shall not exceed 200 mg/m^3 based on a 24-hour average of continuous monitoring. This shall be verified by manual stack testing.

1.5 Nitrogen Oxides (NOx)

The GVRD will implement a NOx reduction strategy by July 1996 as required by the BC Ministry of Environment to meet or exceed the BC MSW Criteria limit of 350 mg/m^3, expressed as NO_2 on a 24-hour average of continuous monitoring.

1.6 Hydrogen Chloride (HCl)

Hydrogen chloride emissions shall not exceed 55 mg/m^3 (wet basis), based on manual stack testing methods approved by the Regional Waste Manager.

Continuous monitoring of SO_2 shall be used as a surrogate for emission monitoring of acid gases, such as HCl and HF.

Continuous monitoring of HCl (using a 24 hour average) shall be conducted for reporting purposes until the end of the useful life of the HCl analyzer.

1.7 Hydrogen Fluoride (HF)

Hydrogen fluoride emissions shall not exceed 3 mg/m^3 based on manual stack testing methods approved by the Regional Waste Manager.

1.8 Total Hydrocarbons (THC)

Total hydrocarbon emissions (measured as methane, CH_4) shall not exceed 40 mg/m^3 based on manual stack testing methods approved by the Regional Waste Manager.

Continuous monitoring of carbon monoxide emissions shall be used as a surrogate indicator to monitor combustion efficiencies and the discharge of combustibles, such as total hydrocarbons.

1.9 Trace Metals

Trace metal emissions shall not exceed the following limits based on manual stack testing methods approved by the Regional Waste Manager:

METALS	LIMIT
Total of Cadmium, Mercury, and Thallium	200 $\mu g/m^3$
Total of Arsenic, Cobalt, Nickel, Selenium, and Tellurium	1000 $\mu g/m^3$
Total of Antimony, Lead, Chromium, Copper, Manganese, Vanadium, and Zinc	5000 $\mu g/m^3$
Mercury	200 $\mu g/m^3$
Cadmium	100 $\mu g/m^3$
Lead	50 $\mu g/m^3$

Continuous monitoring of opacity shall be used as a surrogate indicator for trace metal discharges.

1.10 Trace Organics

Trace organic emissions shall not exceed 0.5 ng/m^3 for the sum of PCDD and PCDF as toxicity equivalents, and 5 $\mu g/m^3$ for polyaromatic hydrocarbons based on manual stack testing methods approved by the Regional Waste Manager. Frequency of manual stack testing shall be as required by the Regional Waste Manager.

1.11 Frequency of Manual Stack Testing

Manual stack testing for trace organics shall be performed as required by the Regional Waste Manager. HF and THC testing shall be conducted annually. SO_2, HCl, particulates and trace metals shall be conducted three times in both 1995 and 1996. If the results of these tests are satisfactory, frequency will be reduced to annual testing.

2.0 Additional Monitoring and Reporting

2.1 Furnace Temperature

Furnace reference temperature for each incinerator unit shall be monitored and reported with a minimum of 800°C based on a 1-hour averaging time during normal operating conditions.

2.2 Emission Control Device Temperature

Emission control device temperature shall not exceed a temperature of 190°C based on a 1-hour averaging time.

2.3 Monitoring of Oxygen

Oxygen shall be continuously monitored and reported as a percentage of stack gas on a 1-hour averaging basis.

2.4 Flowrate and Operating Period

The flue gas flow rate for each incinerator unit shall not exceed 1200 m^3/minute for a continuous operating period.

2.5 Availability

The monthly availability of the SO_2 continuous monitor shall be at least 90%. Opacity, oxygen, carbon monoxide, reference furnace temperature, and emission control device outlet temperature shall have a monthly availability of at least 95%.

The Regional Waste Manager shall be notified of any continuous monitor failure for a period which may result in non-attainment of the recommended availability. If immediate corrective action was taken to return the monitor to service, compliance shall be granted providing the District can supply evidence (operating and emission data) indicating that the facility was in normal continuous operation.

2.7 Monthly Reporting

Monthly reports shall include compliance summaries for all parameters with specified limits.

Tabulated hourly averaged data and data based on required averaging periods of all continuously monitored parameters, including availability and data capture information, shall be available for inspection but not included in the monthly report.

Raw data shall be maintained and available for inspection at the incinerator site for a minimum period of two years.

2.8 Annual Reporting

An annual report shall be provided within 90 days following the end of the calendar year. The report shall consolidate and summarize the monthly data as well as briefly summarize the topics itemized in Section 6.3 of the BC MSW Criteria.

2.9 Start-up, Shutdown and Upset Conditions

During start-up, shutdown, equipment malfunction and operating upsets requiring shutdown (i.e. ash discharge or feed chute plugging), emission data recorded by the CEMS shall be excluded from the regulatory emission averaging calculations.

When required, the time, duration, and reason for an occurrence during transient conditions shall be reported to the Ministry. The corrective action taken by the operator in attempting to return the operation to steady-state conditions shall be included in the report.

APPENDIX F

Supplemental Information

APPENDIX F-1

Canadian Health Measures Survey (CHMS)

Overview of the Canadian Health Measures Survey

Policy makers, provincial health departments, researchers and health professionals from many fields have expressed a need for a national, comprehensive source of accurate health measures to assist them in addressing the health needs of all Canadians.

In 2003, Health Canada and the Public Health Agency of Canada supported Statistics Canada in obtaining funding for a ‘direct measures’ health survey to address longstanding limitations within Canada’s health information system. This support was announced in the 2003 federal budget as part of an extension of the Health Information Roadmap Initiative.

The Canadian Health Measures Survey (CHMS), launched in 2007, is collecting key information relevant to the health of Canadians by means of direct physical measurements such as blood pressure, height, weight and physical fitness. As part of the CHMS, a clinical oral health examination helps to evaluate the association of oral health with major health concerns such as diabetes and respiratory and cardiovascular diseases. In addition, the survey is collecting blood and urine samples to test for chronic and infectious diseases, nutrition and environment markers.

Through household interviews, the CHMS is gathering information related to nutrition, smoking habits, alcohol use, medical history, current health status, sexual behaviour, lifestyle and physical activity, the environment and housing characteristics, as well as demographic and socioeconomic variables.

All of this valuable information will create national baseline data on the extent of such major health concerns as obesity, hypertension, cardiovascular disease, exposure to infectious diseases, and exposure to environmental contaminants. In addition, the survey will provide clues about illness and the extent to which many diseases may be undiagnosed among Canadians. The CHMS will enable us to determine relationships between disease risk factors and health status, and to explore emerging public health issues.

In the last 35 years, some Canadian surveys have collected direct physical measures:

- Nutrition Canada Survey (1970-72)
- Canada Health Survey (1978)
- Canadian Heart Health Surveys (1988-92)
- Canadian Study of Health and Aging (1992)
- Canadian Community Health Survey, Cycle 2.2 (2004)

Many countries have a long history of surveys including direct physical measures that have led to important findings.
In the United States, for example, the National Health and Nutrition Examination Survey (NHANES) has helped develop the standard growth charts for children, thereby allowing doctors and parents to better understand the developmental health and well-being of children.

The American survey’s biggest impact was probably its findings about the link between high cholesterol and heart disease in the 1960s. The same survey also gave the first evidence that Americans had too much lead in their blood, lead contamination being related to learning disabilities and other health problems. This pushed the government to phase out the use of lead as an additive in gasoline.

In Australia, a similar survey conducted from 1999 to 2001 found that, for every known case of diabetes, there was one undiagnosed case. Furthermore, nearly 1 million Australians over the age of 25 have diabetes. These data are important for Australia’s national and regional public health education, health promotion programs and health care planning.

In New Zealand, the 1996-97 health and nutrition surveys have shown three key nutrition problems in population: obesity, food security and calcium inadequacy. These are all now priorities within New Zealand’s Ministry of Health for policy work to develop prevention programs.

All of these improvements would not have been made possible without the information gathered through measurements of physical characteristics. Many health professionals and organizations in Canada recognize the need for a physical measures survey and, accordingly, key organizations have provided their endorsement and support. The CHMS has received the endorsement of

- the Canadian Medical Association
- the Canadian Dental Association
- the Heart and Stroke Foundation of Canada
- The Canadian Lung Association
- the Canadian Red Cross
- Dietitians of Canada
- the Canadian Hypertension Society

and the support of

- the College of Family Physicians of Canada
- the Canadian Public Health Association.

Survey content

Canada is currently relying on self-reported information, isolated clinical studies and U.S. data to make estimates on the health status of Canadians. The Canadian Health Measures Survey (CHMS) is collecting health information about Canadians that cannot be otherwise captured or that may be inaccurately reported through self-report questionnaires or health care records. Hospital and medical records do provide data, but only on those who have received or are undergoing treatment, or on those who seek medical advice regularly.

The CHMS is overcoming these data gaps by collecting physical measures from a random sample of the Canadian population, thereby including individuals at varying levels of health who may or may not seek medical treatment. By examining such a cross-section of the population, the CHMS will strive to provide an estimate of the number of Canadians who show signs of a previously-undetected illness, or who may be unaware that they have a condition.

Several consultations took place with various stakeholders to determine a list of high priority variables that are being measured in the CHMS and to finalize the exact survey content.

The following are some of the measures that the CHMS includes:

Physical measures

- Anthropometry (standing height, sitting height, weight, waist circumference, hip circumference, skinfolds)
- Cardiovascular fitness (blood pressure, modified Canadian Aerobic Fitness Test)
- Musculoskeletal fitness (hand grip strength, sit and reach test, partial curl-ups)
- Physical activity (accelerometry)
- Lung function (spirometry)
- Oral health (clinical oral examination)

Blood measures

- Nutritional status (e.g., folate, calcium)
- Metabolic syndrome (e.g., indicators of pre-diabetes)
- Cardiovascular disease (e.g., lipid profile)
- Environmental exposure (e.g., lead, mercury)
- Infectious disease markers (e.g., hepatitis)

Urine measures

- Indicators of kidney disease (e.g., microalbumin, creatinine)
- Environmental exposure (e.g., cotinine, pesticides)
- Nutritional markers (e.g., iodine)

The CHMS stores biological samples for further analyses of measures at a later date. The CHMS team works closely with the Health Canada Research Ethics Board and the Office of the Privacy Commissioner of Canada in order to address privacy issues and to implement proper laboratory procedures.

Survey operations

The first cycle of the Canadian Health Measures Survey (CHMS) will collect measures from approximately 5,000 people representing around 97% of the Canadian population aged 6 to 79. The survey collection began in early 2007 and will continue until early 2009. Initial data dissemination is planned for early 2010. In 2008, ongoing funding was officially approved for future cycles of the CHMS. The survey can now become an ongoing part of Canada’s health information system. The second cycle of data collection is scheduled to begin in August 2009.

The CHMS is collecting data in 15 sites across the country. For the first cycle, the collection sites are located in five provinces: New Brunswick, Quebec, Ontario, Alberta and British Columbia. Collection includes a combination of a personal interview using a computer-assisted interviewing method and a visit to a mobile clinic specifically designed for the survey’s collection of the physical measures.The CHMS mobile clinic remains in each site for six to eight weeks collecting direct measures from approximately 350 respondents per site.

First step: personal interview at the household

The first contact with respondents is a letter sent through the mail. The letter informs people living at the sampled address that an interviewer will visit their home to collect some information about the household.

When visiting the home, the interviewer randomly selects one or two respondents and conducts a health interview. The interview should take 45 to 60 minutes per respondent. The interviewer assists each respondent in setting an appointment for the physical measures to be taken by health professionals at the CHMS mobile clinic.

Second step: visit to the CHMS mobile clinic

The CHMS uses mobile clinics to conduct the clinic portion of the survey. Similar clinics have been used successfully for years by the NHANES in the United States.

The clinic consists of two trailers linked by an enclosed pedestrian walkway. One trailer serves as a reception and administration area, while the other contains clinic rooms and a laboratory.

For each respondent, the complete visit to the centre lasts about two hours. This is an approximate time, given that each respondent is assessed for the suitability of each measure and tested accordingly.

At the end of the visit to the mobile clinic, respondents are provided with a waterproof activity monitor. This small device is to be worn for a week at all times except when sleeping—even when swimming or bathing. It will record information about normal physical activity patterns without the respondents having to do anything special. When the seven-day period is over, respondents will return the monitor in a special prepaid envelope they are given for this purpose.

Test results

If respondents so desire, they will receive a preliminary report of their test results before leaving the mobile clinic. A few months after their visit, the respondents’ laboratory test results will be sent to them.

Confidentiality and consent

The Canadian Health Measures Survey is conducted under the authority of the *Statistics Act.* Participation in this survey is voluntary. Respondents are asked to give their written consent for the clinic portion of the survey.

Consultations

The survey's content and methods were developed in consultation with Health Canada, the Public Health Agency of Canada and three advisory committees: the Expert Advisory Committee, the Physician Advisory Committee and the Laboratory Advisory Committee. Extensive consultations were held with experts from the NHANES in order to validate the protocols for the measures.

Throughout the process, consultations were held on a monthly basis with the Health Canada Research Ethics Board. Several meetings were also held with the Office of the Privacy Commissioner of Canada and with provincial privacy commissioners. A Privacy Impact Assessment has been presented to the Office of the Privacy Commissioner.

Pre-test of the survey

A successful test of the Canadian Health Measures Survey (CHMS) was conducted in the fall of 2004. The objectives of the pre-test—to determine logistics, cost, time required to conduct all aspects of the survey, procedures, participation rates, etc.—were met with success. A dress rehearsal was conducted in early 2007. The lessons learned from the pre-test of the survey and the dress rehearsal were applied to the actual survey.

The participation rate in the pre-test was considered satisfactory by Statistics Canada. Respondents of all ages agreed to participate in the selected direct measures (physical and biological tests), with more than 90% of those who attended the clinic agreeing both to the physical measures and to give blood and urine samples. The lessons learned in the pre-test helped us achieve an even better response to the survey when the CHMS entered the field in 2007.

The pre-test survey data could not provide any statistical inferences about the Canadian population, but the data did provide interesting information about the sample population. One such finding of the pre-test was that self-reported measures are not as accurate as direct measures. For example:

- For body mass index (BMI), 20% of respondents were misclassified: the most common reclassifications for adults were from normal to overweight, and from overweight to obese. Height was reported accurately, but weight was under-reported by all age groups.

- For hypertension, nearly one-fifth of respondents were hypertensive. Of those, less than half were actually aware that they had high blood pressure.

The overall lessons learned were that Canadians seem interested in, and supportive of, a survey of this nature, and that the CHMS will be able to yield quality data on the health status of the Canadian population. This is good news, given that the CHMS represents a wealth of new information for public health professionals and researchers.

For more information

For more information on the Canadian Health Measures Survey, please contact the Statistics Canada regional office nearest you, send an e-mail to chms-ecms@statcan.gc.ca or visit www.statcan.gc.ca/chms.

Aussi disponible en français.

APPENDIX F-2

Maternal-Infant Research on Environmental Chemicals (MIREC)

Maternal-Infant Research on Environmental Chemicals (The MIREC Study)

The Issue

Recent reports have raised concerns about the number of chemicals in our bodies and the health effects, if any, which may be associated with the levels measured. Reliable data on the levels of environmental chemicals of concern in Canadians are limited. Major technological advances in the analysis of chemicals mean that extremely low levels can now be detected in body fluids, tissues and hair. Therefore it is not unusual to find very small levels of chemicals in the urine or blood of participants given that we come across many of these chemicals in our everyday life. It is well known that high levels of some chemicals, such as lead and mercury, do cause health effects. What is not always clear is whether there are any measurable health effects from lower levels of exposure. The Canadian Health Measures Survey (2007-09) is expected to provide much needed national data on exposure of the Canadian population to several important environmental contaminants; however, this survey will not collect data for two of the most susceptible and vulnerable populations: the pregnant woman and her baby.

As awareness of the presence of environmental chemicals in humans is increasing, Canada as well as other countries, are studying pregnant women in order to better understand their exposure to these chemicals. Although breast feeding is known to be the best method for feeding infants, recent Canadian information on environmental chemicals found in breast milk is limited. There have also been few national studies that have specifically measured the nutrients and immuno-protective factors that are found in breast milk.

Smoking in pregnancy has long been linked with a higher risk of low birth weight, and other harmful effects on the baby. Currently, there is little Canadian information about the extent to which women are exposed to tobacco smoke during pregnancy. As well, there is limited information on whether smoking behaviour changes during pregnancy.

Given these data gaps, scientists at Health Canada and their academic and clinical research collaborators have designed and are now carrying out the study known as the Maternal-Infant Research on Environmental Chemicals (MIREC).

Description of the MIREC Study

MIREC is a national five-year research study that is recruiting about 2,000 women from the following cities: Vancouver, Calgary, Winnipeg, Sudbury, Ottawa, Kingston, Hamilton, Toronto, Montreal and Halifax. Women will be recruited during the first trimester of pregnancy and followed through pregnancy and up to eight weeks after birth. Participants must be 18 years of age or older and six to 12 weeks pregnant to be eligible for the study. The main goals of this study are:

1. To measure the extent to which pregnant women and their babies are exposed to environmental chemicals, as well as tobacco smoke;
2. To assess what pregnancy health risks, if any, are associated with exposure to heavy metals (lead, mercury, cadmium, arsenic and manganese);
3. To measure the levels of environmental chemicals and some of the beneficial components (nutritional and immune constituents) of breast milk.

Biological markers of environmental chemicals and tobacco smoke exposure will be measured in the mothers' blood, urine, hair, and breast milk and in their babies' umbilical cord blood and meconium (which is the baby's first stool). Mothers will also be asked to complete questionnaires throughout their pregnancy and after birth.

The MIREC study is a collaborative effort among Health Canada scientists, the Sainte-Justine Hospital in Montreal, and clinical researchers from the other participating cities. Sainte-Justine Hospital in Montreal is the coordinating centre for the study. Laboratories at the Centre de Toxicologie du Québec and Health Canada will conduct the analysis of tissues and fluids.

MIREC and Biomonitoring

Biomonitoring is the measurement of a chemical substance (or the breakdown products of that substance) in human tissues or fluids. Measurements are usually taken in blood and urine, and sometimes in hair, saliva or breast milk. Biomonitoring studies that focus on sub-populations such as pregnant women can help us compare levels of exposure for a particular group to the broader population. The MIREC study complements the Canadian Health Measures Survey, launched in early 2007 by Statistics Canada, which is collecting biological samples and information on health, lifestyle and environmental chemicals from 5,000 Canadians between the ages of six and 79 years.

The MIREC study will measure heavy metals such as lead, mercury, arsenic, manganese and cadmium, as well as other chemicals including:

- phthalates and bisphenol A, which are used to make plastics and vinyl;
- PBDEs (polybrominated diphenyl ethers), which are added to products to make them less likely to catch fire;
- organochlorine pesticides, which are no longer registered for use in Canada, but continue to persist in the environment.
- organophosphate pesticides, most of which are used for insect control and usually do not persist in the environment;
- PCBs (polychlorinated biphenyls), formerly used as an ingredient in many industrial materials;
- cotinine, which is a by-product of smoking; and
- perfluorinated compounds, which are used in the manufacture of grease and water repellents used on products.

Health Canada's Role

The MIREC study is a key deliverable under the Government of Canada's Chemicals Management Plan. Launched in December 2006, the Plan is a significant step forward in reducing the impact of environmental chemicals on human health and the environment.

MIREC is co-funded by Health Canada, the Canadian Institutes of Health Research (CIHR) and the Ontario Ministry of the Environment.

Public Health Relevance

The MIREC study will generate new knowledge on Canadians' exposure to environmental chemicals. This information will help to strengthen health risk assessments and support measures to reduce the release of contaminants into the environment and to limit Canadians' exposure.

SOURCE: http://www.hc-sc.gc.ca/ewh-semt/contaminants/mirec/ (Visited December 22, 2008)

APPENDIX F-3

National Health and Nutrition Examination Survey (NHANES)

SAFER • HEALTHIER • PEOPLE™

National Health and Nutrition Examination Survey, 2007-2008

Overview

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Center for Health Statistics

Introduction

The National Health and Nutrition Examination Survey (NHANES) is a program of studies designed to assess the health and nutritional status of adults and children in the United States. The survey is unique in that it combines interviews and physical examinations. NHANES is a major program of the National Center for Health Statistics (NCHS). NCHS is part of the Centers for Disease Control and Prevention (CDC) and has the responsibility for producing vital and health statistics for the Nation.

The NHANES program began in the early 1960s and has been conducted as a series of surveys focusing on different population groups or health topics. In 1999, the survey became a continuous program that has a changing focus on a variety of health and nutrition measurements to meet emerging needs. The survey examines a nationally representative sample of about 5,000 persons each year. These persons are located in counties across the country, 15 of which are visited each year.

The NHANES interview includes demographic, socioeconomic, dietary, and health-related questions. The examination component consists of medical, dental, and physiological measurements, as well as laboratory tests administered by highly trained medical personnel.

Findings from this survey will be used to determine the prevalence of major diseases and risk factors for diseases. Information will be used to assess nutritional status and its association with health promotion and disease prevention. NHANES findings are also the basis for national standards for such measurements as height, weight, and blood pressure. Data from this survey will be used in epidemiological studies and health sciences research, which help develop sound public health policy, direct and design health programs and services, and expand the health knowledge for the Nation.

Survey Content

As in past health examination surveys, data will be collected on the prevalence of chronic conditions in the population. Estimates for previously undiagnosed conditions, as well as those known to and reported by respondents, are produced through the survey. Such information is a particular strength of the NHANES program.

Risk factors, those aspects of a person's lifestyle, constitution, heredity, or environment that may increase the chances of developing a certain disease or condition, will be examined. Smoking, alcohol consumption, sexual practices, drug use, physical fitness and activity, weight, and dietary intake will be studied. Data on certain aspects of reproductive health, such as use of oral contraceptives and breastfeeding practices, will also be collected.

The diseases, medical conditions, and health indicators to be studied include:

- Anemia
- Cardiovascular disease
- Diabetes
- Environmental exposures
- Eye diseases
- Hearing loss
- Infectious diseases
- Kidney disease
- Nutrition
- Obesity
- Oral health
- Osteoporosis

- Physical fitness and physical functioning
- Reproductive history and sexual behavior
- Respiratory disease (asthma, chronic bronchitis, emphysema)
- Sexually transmitted diseases
- Vision

The sample for the survey is selected to represent the U.S. population of all ages. To produce reliable statistics, NHANES over-samples persons 60 and older, African Americans, and Hispanics.

Since the United States has experienced dramatic growth in the number of older people during this century, the aging population has major implications for health care needs, public policy, and research priorities. NCHS is working with public health agencies to increase the knowledge of the health status of older Americans. NHANES has a primary role in this endeavor.

All participants visit the physician. Dietary interviews and body measurements are included for everyone. All but the very young have a blood sample taken and will have a dental screening. Depending upon the age of the participant, the rest of the examination includes tests and procedures to assess the various aspects of health listed above. In general, the older the individual, the more extensive the examination.

Survey Operations

Health interviews are conducted in respondents' homes. Health measurements are performed in specially-designed and equipped mobile centers, which travel to locations throughout the country. The study team consists of a physician, medical and health technicians, as well as dietary and health interviewers. Many of the study staff are bilingual (English/Spanish).

An advanced computer system using high-end servers, desktop PCs, and wide-area networking collect and process all of the NHANES data, nearly eliminating the need for paper forms and manual coding operations. This system allows interviewers to use notebook computers with electronic pens. The staff at the mobile center can automatically transmit data into data bases through such devices as digital scales and stadiometers. Touch-sensitive computer screens let respondents enter their own responses to certain sensitive questions in complete privacy. Survey information is available to NCHS staff within 24 hours of collection, which enhances the capability of collecting quality data and increases the speed with which results are released to the public.

In each location, local health and government officials are notified of the upcoming survey. Households in the study area receive a letter from the NCHS Director to introduce the survey. Local media may feature stories about the survey.

NHANES is designed to facilitate and encourage participation. Transportation is provided to and from the mobile center if necessary. Participants receive compensation and a report of medical findings is given to each participant. All information collected in the survey is kept strictly confidential. Privacy is protected by public laws.

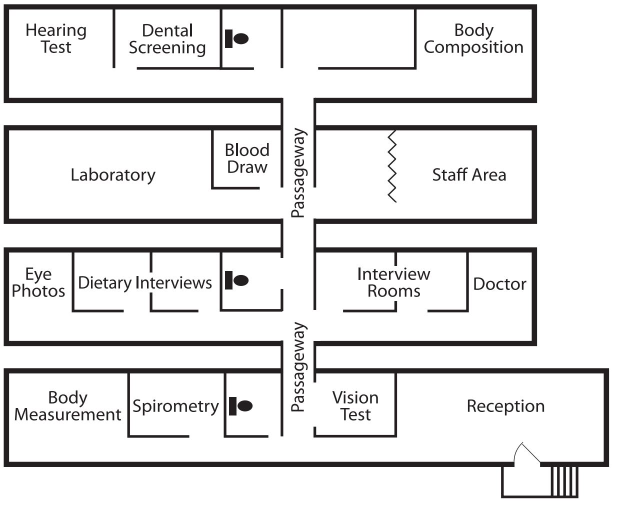
Uses of the Data

Information from NHANES is made available through an extensive series of publications and articles in scientific and technical journals. For data users and researchers throughout the world, survey data are available on the internet and on easy-to-use CD-ROMs.

Research organizations, universities, health care providers, and educators benefit from survey information. Primary data users are federal agencies that collaborated in the design and development of the survey. The National Institutes of Health, the Food and Drug Administration, and CDC are among the agencies that rely upon NHANES to provide data essential for the implementation and evaluation of program activities. The U.S. Department of Agriculture and NCHS cooperate in planning and reporting dietary and nutrition information from the survey.

NHANES' partnership with the U.S. Environmental Protection Agency allows continued study of the many important environmental influences on our health.

Mobile Examination Center (MEC) Diagram



NHANES' record of important accomplishments is made possible by the thousands of Americans who have participated.

- Past surveys have provided data to create the growth charts used nationally by pediatricians to evaluate children's growth. The charts have been adapted and adopted worldwide as a reference standard—and have recently been updated using the latest NHANES figures.

- Blood lead data were instrumental in developing policy to eliminate lead from gasoline and in food and soft drink cans. Recent survey data indicate the policy has been even more effective than originally envisioned, with a decline in elevated blood lead levels of more than 70% since the 1970s.

- Overweight prevalence figures have led to the proliferation of programs emphasizing diet and exercise, stimulated additional research, and provided a means to track trends in obesity.

- Data have continued to indicate that undiagnosed diabetes is a significant problem in the United States. Efforts by government and private agencies to increase public awareness, especially among minority populations, have been intensified.

These are just a few examples of what survey findings have meant. The current program promises continuing contributions and some new initiatives.

- Information collected in this survey will help the Food and Drug Administration decide if there is a need to change vitamin and mineral fortification regulations for the Nation's food supply.

- National programs to reduce hypertension and cholesterol levels continue to depend on NHANES data to steer education and prevention programs toward those at risk and to measure success in curtailing risk factors associated with heart disease, the Nation's number one cause of death.

- New measures of lung function will further our understanding of respiratory disease and better describe the burden of asthma in the United States.

Because NHANES is now an ongoing program, the information collected contributes to annual estimates in topic areas included in the survey. For small population groups and less prevalent conditions and diseases, data must be accumulated over several years to provide adequate estimates. The new continuous design also allows increased flexibility in survey content.

Results of NHANES benefit people in the United States in important ways. Facts about the distribution of health problems and risk factors in the population give researchers important clues to the causes of disease. Information collected from the current survey is compared with information collected in previous surveys. This allows health planners to detect the extent various health problems and risk factors have changed in the U.S. population over time. By identifying the health care needs of the population, government agencies and private sector organizations can establish policies and plan research, education, and health promotion programs that help improve present health status and will prevent future health problems.

For more information about the National Center for Health Statistics contact:

Information Dissemination Staff
National Center for Health Statistics
Room 5412, Metro IV Bldg.
3311 Toledo Road
Hyattsville, MD 20782

Telephone: 1-866-441-NCHS (6247)
E-mail: nchsquery@cdc.gov
Internet: www.cdc.gov/nchs

For more information about the National Health and Nutrition Examination Survey you may visit the NHANES web site at: www.cdc.gov/nhanes

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APPENDIX G

External Contact Review – Contact Results

Contact	Location	Affiliation	Time Difference	Contact Details	Contact Attempt #1		Contact Attempt #2		Contact Attempt #3		Contact Reply Date	Result
					Method	Date	Method	Date	Method	Date		
Incinerator Contacts												
Nordforbraending Incinerator Facility	Denmark	Incinerator Facility	+6	nordf@nordf.dk	Email	10/30/2008	Email	11/19/2008	Phone	12/1/2008	No Reply.	Number does not connect.
Carsten Spohn	Germany	German EFW Association, ITAD	+6	spohn@itad.de	Email	10/30/2008	Email	11/19/2008	Phone	12/1/2008	12/1/2008	Spoke with Mr. Spohn and interviewed him, minutes confirmed.
Francesca Faraon	Italy	IDECOM, for VESTA Incinerator	+6	francesca@idecom.it	Email	10/30/2008	Email	12/1/2008	N/A	N/A	11/14/2008	Referred to Gianni Teardo and will act as go-between - Request for Written Questionnaire - Questionnaire Sent 11/17
Gianni Teardo	Italy	Ecoprogretto Venezia, for VESTA Incinerator	+6	teardo@ecoprogrettovenezia.it	Email	10/30/2008	Email	12/1/2008	Phone	12/5/2008	No Reply.	Followed up on Questionnaire by email on 12/1 as no response received in 2 weeks. Attempted phone call on 12/5 - number does not connect.
Lorenzo Zaniboni	Italy	ASM Brescia Incinerator Facility	+6	lzaniboni@asm.it	Email	10/30/2008	Email	11/19/2008	Phone	12/5/2008	No Reply.	Telephone Number does not connect.
Domenico Lunghi	Italy	AMSA Silla 2 Incinerator Facility	+6	domenico.lunghi@amsa.it	Email	10/30/2008	Email	11/19/2008	N/A	N/A	11/19/2008	Mr. Lunghi no longer works at AMSA Silla 2. Sent an email to a communications representative in the hopes of getting in touch with a knowledgeable person at this facility. No response.
Giuseppe Sgorbati	Italy	Regional Agency for the Protection of the Environment	+6	g.sgorbati@arpalombardia.it	Email	10/30/2008	Email	11/19/2008	N/A	N/A	11/21/2008	Referred to Silvana Angius, representative for Emissions.
Håkan Rylander	Sweden	SYSAV EFW Facility	+6	hakan.rylander@sysav.se	Email	10/30/2008	Email	11/19/2008	Phone	12/1/2008	No Reply.	Phone number leads to directory, in swedish. Have spoken with Mr. Eek. No need to further contact Mr. Rylander.
Jonas Eek	Sweden	SYSAV EFW Facility	+6	jonas.eek@sysav.se	Email	10/30/2008	Email	11/19/2008	Phone	12/1/2008	12/1/2008	Spoke with Mr. Eek and interviewed him, minutes confirmed.
Oswald Looser	Switzerland	Hagenholz EFW Facility	+6	oswald.looser@zuerich.ch	Email	10/30/2008	Email	11/19/2008	Phone	12/5/2008	No Reply.	Left message on voice mail. No reply from Mr. Looser.

Contact	Location	Affiliation	Time Difference	Contact Details	Contact Attempt #1		Contact Attempt #2		Contact Attempt #3		Contact Reply Date	Result
					Method	Date	Method	Date	Method	Date		
Research and Academic Contacts												
Fatima Reis	Portugal	University of Lisbon	+5	mfreis@fm.ul.pt	Email	11/3/2008	Email	11/17/2008	Phone	12/11/2008	12/11/2008	Agreed to participate via written response to questionnaire. Questionnaire sent 12/11.
J.L. Domingo	Spain	Rovira i Virgilli University	+6	joseluis.domingo@urv.cat	Email	11/3/2008	N/A	N/A	N/A	N/A	11/3/2008	Agreed to participate. Was sent the questionnaire and replied in writing on 11/4.
Greet Schoeters	Belgium	Flemish Centre for Environment and Health	+6	greet.schoeters@vito.be	Email	11/3/2008	Email	11/17/2008	Phone	12/1/2008; 12/5/2008	12/5/2008	Spoke on the phone with Dr. Schoeters 12/5/08
Reinhard Joas	Germany	BiPRO GMBH (Consulting)	+6	reinhard.joas@bipro.de	Email	11/3/2008	Email	11/17/2008	Phone	11/26/2008 ; 12/5/2008	No Reply.	Unavailable at time of call. Left contact information, will call back. Called again 12/5/08, left message once again with receptionist. No reply once again.
Elena De Felip	Italy	National Institute of Health	+6	defelip@iss.it	Email	11/3/2008	Email	11/17/2008	Phone	11/26/2008	11/26/2008	Sent questionnaire for answering. She also forwarded questionnaire to ISS expert in MWIs. Attempted contact 12/4/08 to follow up on questionnaire. No response.
Giuseppe Viviano	Italy	National Institute of Health	+6	giuseppe.viviano@iss.it	Email	11/26/2008	Email	12/4/2008	N/A	N/A	No Reply.	No phone number available. No replies to email.
Nadine Frery	France	National Institute of Public Health Surveillance	+6	n.frery@invs.sante.fr	Email	11/3/2008	Email	11/17/2008	Phone	11/26/2008 ; 12/5/2008	12/5/2008	Spoke on the phone with Dr. Frery 12/5/08.
Sebastien Fierens	Belgium	Universite Catholique de Louvain, Belgium	+6	Sebastien.Fierens@toxi.ucl.ac.be	Email	11/17/2008	Phone/ Email	11/26/2008	Phone	12/5/2008	No Reply.	No answer at office after 2 phone attempts.
Laura Green	United States	Cambridge Environmental	0	green@ cambridgeenvironmental.com	Email	12/4/2008	Phone	12/5/2008	N/A	N/A	12/5/2008	Interviewed on phone. Also referred to Steve Zemba. Minutes confirmed.
Stephen Zemba	United States	Cambridge Environmental	0	zemba@ cambridgeenvironmental.com	Email	12/5/2008	Phone	12/11/2008	N/A	N/A	12/11/2008	Referred to Matt Lorber

Contact	Location	Affiliation	Time Difference	Contact Details	Contact Attempt #1		Contact Attempt #2		Contact Attempt #3		Contact Reply Date	Result
					Method	Date	Method	Date	Method	Date		
Government Contacts												
Birgit Van Tongelen	EU	EU Environment Ministry	+6	birgit.van-tongelen@ec.europa.eu	Email	11/3/2008	Email	11/17/2008	Phone	11/26/2008	11/26/2008	Briefly Responded to Questions Asked. Minutes confirmed in writing.
Silvana Angius	Italy	Regional Agency for the Protection of the Environment	+6	s.angius@arpalombardia.it	Email	11/21/2008	Phone/ Email	12/5/2008	N/A	N/A	12/5/2008	Agreed to participate. Questionnaire sent. No answer on phone, sent email 12/5. Phone interview scheduled for 12/11.
Silvia Saldanha	Portugal	Portugal Ministry of Environment	+5	silvia.saldanha@iambiente.pt	Email	11/3/2008	Email	11/17/2008	Phone	12/1/2008; 12/3/2008	No Reply.	No answer after 2 phone calls.
Cesaltina Maria Correia Ramos	Portugal	Portugal Ministry of Health	+5	Cramos@dgsaude.min-saude.pt	Email	11/3/2008	Email	11/17/2008	Phone	12/1/2008; 12/3/2008	No Reply.	No answer after 2 phone calls.
Eva Dressler	Germany	Federal Ministry for the Environment	+6	eva.dressler@bmu.bund.de	Email	11/3/2008	Email	11/17/2008	N/A	N/A	11/4/2008	No longer posted to Human Biomonitoring, will forward email to new people responsible - Wolz and Kullmer.
Birgit Wolz	Germany	Federal Ministry for the Environment	+6	birgit.wolz@bmu.bund.de	Email	11/17/2008	Email	11/26/2008	N/A	N/A	11/27/2008	Believes she does not possess any information that can help us.
Jens Kullmer	Germany	Federal Ministry for the Environment	+6	jens.kuellmer@bmu.bund.de	Email	11/17/2008	Email	11/26/2008	N/A	N/A	11/19/2008	Mr. Kullmer has asked the Federal Environment Agency to send us an answer. No response received and Mr. Kullmer is no longer responding himself. Do not have a phone number.
Pierre Biot	Belgium	Federal Ministry for the Environment	+6	pierre.biot@health.fgov.be	Email	11/3/2008	Email	11/17/2008	N/A	N/A	11/18/2008	Referred to Reis, Schoeters (already contacted) and Laurence Nick.
Laurence Nick	Belgium	DGASS, Walloon Region	+6	l.nick@mrw.wallonie.be	Email	11/19/2008	Email	11/26/2008	N/A	N/A	11/27/2008	Forwarded to F. Brancart, Environmental Administration
F. Brancart	Belgium	Walloon Region	+6	f.brancart@mrw.wallonie.be	Email	11/27/2008	Email	12/4/2008	N/A	N/A	No Reply.	No phone number available.
Lars Fock	Denmark	Danish Environmental Protection Agency	+6	lfo@mst.dk	Email	11/17/2008	Email	11/26/2008	Phone	12/5/2008	No Reply.	No answer at office.
Lis Keiding	Denmark	National Board of Health	+6	lke@sst.dk	Email	11/17/2008	N/A	N/A	N/A	N/A	11/19/2008	Referred to Danish Environmental Protection Agency (Lars Fock)
Ellen Lee	Canada	Health Canada	--	ellen_lee@hc-sc.gc.ca	Email	12/9/2008	N/A	N/A	N/A	N/A	12/9/2008	Contacted by C. Ollson. Provided information on CHMS and availability of data.
Andrew Neill	Canada	MOE	--	andrew.neill@ontario.ca	Email	12/11/2008	N/A	N/A	N/A	N/A	12/22/2008	Contacted by J. McKay. Provided C of A's for a number of facilities.
Stuart Lockwood	Canada	Metro Vancouver	-3	Stewart.Lockwood@ metrovancouver.org	Email	12/9/2008	N/A	N/A	N/A	N/A	12/9/2008	Provided Metro Vancouver Waste Report outlining monitoring requirements of EFW in Burnaby. Also assisted in identification of other useful contacts within Metro Vancouver.
Goran Krstic	Canada	Fraser Health Authority	-3	goran.krstic@fraserhealth.ca	Email	1/7/2009	N/A	N/A	N/A	N/A	1/8/2009	Conference call with Dr. Krstic and Stewart Lockwood on 1/8/08. Minutes confirmed.
Chris Allan	Canada	Metro Vancouver	-3	chris.allan@metrovancouver.org	Phone	1/9/2009	N/A	N/A	N/A	N/A	9/1/2009	Interviewed on phone. Minutes Confirmed.
Ken Reid	Canada	Metro Vancouver	-3	ken.reid@metrovancouver.org	Phone	1/7/2009	Phone	1/9/2009	N/A	N/A	12/1/2009	Spoke to Ken on the phone. Confirmed information received from Chris Allan. Provided reports of environmental monitoring program.
Matthew Lorber	United States	US EPA	0	lorber.matthew@epa.gov	Email	12/11/2008	Phone	12/18/2008	N/A	N/A	12/18/2008	Provided some written resources on past projects conducted.

Carsten Spohn, ITAD, Germany – Correspondence

From: Carsten Spohn [mailto:spohn@itad.de]
Sent: Tuesday, December 02, 2008 10:30 AM
To: Morin, Mathieu
Subject: AW: Phone Call Summary - Dec 1st, 2008

Dear Mr. Morin

The minutes of our telephone interview are correct.

Mit freundlichen Grüßen
Best regards

Carsten Spohn

Geschäftsführer
Managing Director

ITAD e.V.
Eichhornstr. 5
D-97070 Würzburg

VR Würzburg 2016
Vorstandsvorsitzender: Ferdinand Kleppmann
Geschäftsführer: Carsten Spohn

Tel.: +49 (0) 931 / 660 58 52
Fax: +49 (0) 931 / 660 58 20
Mail: spohn@itad.de
Web: www.itad.de

Von: Morin, Mathieu [mailto:Mathieu.Morin@JacquesWhitford.com]
Gesendet: Montag, 1. Dezember 2008 18:10
An: spohn@itad.de
Cc: Ollson, Christopher; Payne, David
Betreff: Phone Call Summary - Dec 1st, 2008

Dear Mr. Spohn,

Thank you for your time and assistance earlier today on the telephone. Your knowledge will be very valuable to our review.

I would appreciate if you could confirm for me that you provided the following information:

- EFW facilities in Germany conduct emissions monitoring, at the stack for typically expected airborne pollutants, but do not conduct comprehensive environmental surveillance programs (i.e. human biomonitoring, soil/air monitoring) to assess the impact of the facility to the neighboring areas.
- There are more than 100 ambient air monitoring stations in Germany to collect data on the impact of industrial activities in general.

- All EFW plants in Germany are wastewater free, in that any process wastewater is recycled back into the process.
- EFW facilities are regulated by the National Ministry of the Environment, which has a special department dedicated to industrial emissions.
- Human biomonitoring is not conducted because emissions levels are too small to be detected and attributed to EFW facilities.
- The European Union is preparing a new industrial emissions directive, however this will not likely impact the state of affairs in Germany as current German regulations are considerably more strict than the EU directive.

If any of the above is inaccurate or incorrect, please advise.

Regards,

Mathieu Morin, M.Env.Sc.
Study Team Member

Jonas Eek, SYSAV, Sweden – Correspondan ce

From: Jonas Eek [mailto:Jonas.Eek@sysav.se]
Sent: Tuesday, December 02, 2008 8:00 AM
To: Morin, Mathieu
Subject: SV: Phone Call Summary - Dec 1st, 2008

Dear Mr Morin,

It seems to be OK!
It is only two small changes that I have market red in your text.

Good Luck!

Med vänlig hälsning / Best regards

Jonas Eek
Avd.chef Energiavd / Manager - Energy Department
SYSAV

Postal address:	Box 50344, SE-202 13 Malmö, Sweden
Visiting address:	Spillepengsgatan 13
Phone swb:	+46 40-635 18 00
Direct/Mobile:	+46 40-635 18 51
Fax:	+46 40-635 18 90
E-mail:	jonas.eek@sysav.se
Homepage:	www.sysav.se

Från: Morin, Mathieu [mailto:Mathieu.Morin@JacquesWhitford.com]
Skickat: den 1 december 2008 18:24
Till: Jonas Eek
Kopia: Ollson, Christopher; Payne, David
Ämne: Phone Call Summary - Dec 1st, 2008

Dear Mr. Eek,

Thank you for your time and assistance earlier today on the telephone. Your knowledge will be very valuable to our review.

I would appreciate if you could confirm for me that you provided the following information:

- Energy-from-Waste facilities are regulated by the National Environmental Court, which must provide a permit to facilities in order for them to operate.
- This permit outlines the emission targets that the facility must meet, and is specific to the facility and its location/circumstances.
- When applying for the permit, an environmental impact assessment is completed, which includes modeling the impact of the facility's emissions on the surrounding area, but no actual measurements are taken in this process.

- Stack emissions are continuously monitored and an annual environmental report is a mandatory requirement of the facility permit.
- There are no facilities that you have come across that conduct environmental surveillance (of any kind - remove). As long as the facility fulfills the requirements of their permit and publishes their annual environmental report, then all is business as usual.
- To your knowledge, there are no anticipated changes to the way facilities are regulated in your country in the near future. Facilities are bound to the EU directive and levels are frequently lower than these established guidelines.

If any of the above is inaccurate or incorrect, please advise.

Regards,

Mathieu Morin, M.Env.Sc.
Study Team Member

Birgit Van Tongelen, EU – Correspondence

From: Birgit.Van-Tongelen@ec.europa.eu [mailto:Birgit.Van-Tongelen@ec.europa.eu]
Sent: Monday, January 05, 2009 8:22 AM
To: Morin, Mathieu
Cc: Ollson, Christopher
Subject: RE: Follow-Up to Phone Call - International Review of Environmental Surveillance Practices

Confirmed !

Dr. Birgit VAN TONGELEN
Policy Officer
European Commission
DG Environment
Unit B3 - Biotechnology, Pesticides & Health
Avenue de Beaulieu 9, Office 6/171
B-1160 Brussels
Tel. +32-2-299 67 64 - Fax. +32-2-299 43 62
E-mail: birgit.van-tongelen@ec.europa.eu

From: Morin, Mathieu
Sent: Friday, November 28, 2008 2:38 PM
To: 'birgit.van-tongelen@ec.europa.eu'
Cc: Ollson, Christopher
Subject: Follow-Up to Phone Call - International Review of Environmental Surveillance Practices

Dear Dr. Van Tongelen,

I would like to thank you for your time on the phone on Wednesday in answering my questions.

We would like to use the answers you provided as information in the review we are preparing. In conversation, you noted that to your knowledge, there is no country in the European Union that is legally required to conduct human health or environmental surveillance/monitoring in the vicinity of the facility, and that the extent of the legislation is directed at monitoring of pollutants emitted directly from the incinerator stack. Could you please confirm that this is an accurate statement?

Sincerely,

Mathieu Morin, M.Env.Sc.
Study Team Member

<u>Silvana Angius, Lombardia Region, Italy – Correspondence</u>

From: ANGIUS SILVANA [mailto:S.ANGIUS@arpalombardia.it]
Sent: Thursday, December 11, 2008 11:33 AM
To: Morin, Mathieu
Cc: Ollson, Christopher
Subject: R: Phone Call Summary - Dec 11th

Dear Mr. Morin,
You summary of our phone conversation is very accurate. I have taken the liberty of inserting a couple of minor clarifications, which you will see (in red) below.

- Italy's governmental structure is similar to Canada's. There is a Central government with a Ministry of the Environment. Each region in Italy has its own Regional government, and in turn, there are Regional Ministries of the Environment. Most incinerators are regulated by the Regional Ministries of the Environment, with the exception of the very large (rated thermal input > 300 MWth) incinerators, which are governed at the Central level.
- You are the Responsible Authority for the Air Pollution Unit at the Regional Agency for Environmental Protection of ~~Ministry of the Environment for~~ Lombardia ~~Region~~.
- Italian air emission regulations for incineration facilities follow the European Directive 2000/76/EC, essentially word-for-word.
- All facilities must conduct an Environmental Impact Assessment, and obtain an Integrated Pollution Prevention and Control ~~Assessment~~ authorization prior to construction. If during these investigations, it is deemed necessary, the approval for the facility may require emissions limits that are stricter than those set out in the European Directive.
- Human biomonitoring is not typically done at incineration facilities in Italy, however, environmental monitoring (typically ambient air monitoring) is often required and mandated in the facility authorization. This monitoring typically starts before construction commences in order to establish a baseline.
- An example of this would be the facility in Milan which was required to conduct ambient air monitoring during the first 3-4 years of operation for dioxins and other pollutants in several areas.
- You do not foresee any anticipated changes to the way incineration facilities are regulated in the near future.
- In your opinion, current environmental monitoring practices in Italy are adequate for the protection of the environment and human health as the impact of modern waste incinerators is very small.
- Italy does not have a national human biomonitoring program, however, you are aware of individual human biomonitoring programs that have occurred near major environmental accidents.

Best regards,

Silvana Angius

Responsabile U.O. Aria
Dipartimento Provinciale di Milano

A.R.P.A. della Lombardia
Via Juvara 22
20129 Milano

tel. 02-74872292
fax 02-76110170

Da: Morin, Mathieu [mailto:Mathieu.Morin@JacquesWhitford.com]
Inviato: 11 December, 2008 16:18
A: ANGIUS SILVANA
Cc: Ollson, Christopher
Oggetto: Phone Call Summary - Dec 11th

Dear Dr. Angius

Thank you for your time and assistance earlier today on the telephone. Your knowledge will be very valuable to our review.

I would appreciate if you could confirm for me that you provided the following information:

- Italy's governmental structure is similar to Canada's. There is a Central government with a Ministry of the Environment. Each region in Italy has its own Regional government, and in turn, there are Regional Ministries of the Environment. Most incinerators are regulated by the Regional Ministries of the Environment, with the exception of the very large (> 300 MWh) incinerators, which are governed at the Central level.
- You are the Responsible Authority for the Air Pollution Unit at the Regional Ministry of the Environment for Lombardia Region.
- Italian air emission regulations for incineration facilities follow the European Directive 2000/76/EC, essentially word-for-word.
- All facilities must conduct an Environmental Impact Assessment, and an Integrated Pollution Control Assessment prior to construction. If during these investigations, it is deemed necessary, the approval for the facility may require emissions limits that are stricter than those set out in the European Directive.
- Human biomonitoring is not typically done at incineration facilities in Italy, however, environmental monitoring (typically ambient air monitoring) is often required and mandated in the facility authorization. This monitoring typically starts before construction commences in order to establish a baseline.
- An example of this would be the facility in Milan which was required to conduct ambient air monitoring during the first 3-4 years of operation for dioxins and other pollutants in several areas.
- You do not foresee any anticipated changes to the way incineration facilities are regulated in the near future.
- In your opinion, current environmental monitoring practices in Italy are adequate for the protection of the environment and human health as the impact of modern waste incinerators is very small.
- Italy does not have a national human biomonitoring program, however, you are aware of individual human biomonitoring programs that have occurred near major environmental accidents.

If any of the above is inaccurate or incorrect, please advise.

Regards,

Mathieu Morin, M.Env.Sc.
Study Team Member

M. Fatima Reis, Institute of Preventative Medicine, University of Lisbon, Portugal – Correspondence

Questionnaire for Dr. M. Fatima Reis – Returned in Writing December 17, 2008

General Questions

1. How long have you been involved in environmental and/or human health surveillance programs (i.e. environmental monitoring, human biomonitoring)?
   Almost 9 years, in relation to a MWI near Lisbon, and almost six years concerning a municipal, clinical and slaughterhouse waste incinerator located in the Portuguese Madeira Island. Since 2007, we are also involved in the environmental and health surveillance in relation to the only Portuguese clinical waste incinerator, which is located in Lisbon.

Government

To your knowledge,

2. At what level of government are municipal waste incinerators (MWIs) regulated in your country? What branch/department of the government is responsible for MWI regulations?
   At central level (meaning Environment and Health Ministries), according to national legislation (Decreto-Lei n. 85/2005, 28/April/2005).

   For the environmental issues, MWI regulations are under the responsibility of the Portuguese Agency for Environment and, concerning the health side, of the General Directorate of Health.

3. Are environmental surveillance programs a regulatory requirement for MWIs in your country?
   Yes. They are enforced by national legislation (Decreto-Lei n. 85/2005, 28/April/2005).

4. If yes, what components are required to form a part of such environmental surveillance programs?
   According to European Directives and national legislation, continuous and/or regular punctual monitoring of relevant pollutants emissions is always included in the required environmental surveillance programs. Concerning human exposure or health monitoring, it is not clearly defined in the legislation. Therefore, its inclusion in environmental surveillance programs depends on the fact that it has (or not) been specified in the recommendations of the obligatory Environmental Impact Assessment Study (established by Decreto-Lei n. 197/2005, 8/November/2005) that precedes every new or updated incinerator licensing. These recommendations may afterwards result in the enforcement of those human exposure or health monitoring activities through the official "in favor" Declaration that has to be issued by the Regulator Entity before the incinerator starts operation.

Personal Research Activities

5. Who are the stakeholders in your surveillance programs (i.e. government, industry, etc.)? Was the undertaking of your program initiated by yourself, by the facility or by the government?
   The surveillance programs are undertaken by independent institutions (vg, universities and recognized companies of the environment and health sectors) under contract (following invitation or successful application to a public tender) with the public and/or private entities that explore the incinerators. The reports of the monitoring activities are sent to these entities that are obliged to send them to a Steering Committee, which includes relevant stakeholders (from national and municipal institutions, NGOs and representative of the general Public) nominated by the Regulatory Entity.

6. What is the general scope of your surveillance activities?
   Our surveillance activities usually include monitoring of human exposure to heavy metals and dioxins (PCDD/Fs and PCBs), using human biomonitoring strategies, and of associated adverse health effects, by questionnaire administration and/or analysis of health registries.

7. Have all your results been published in the primary literature, and if not, what information on unpublished studies can you provide us?
   All our relevant results are usually published in the primary literature.

8. Do you follow any particular best practices for surveillance and if so, have these been publicly documented or published?
   Our publications include always the description of the relevant details of our methodological strategies.

9. What have been the general outcomes of your studies? Have they provided useful, measurable results?
   Demonstration of statistically not significant differences between potentially exposed populations and those taken as control.
   Yes, mainly those concerned with human exposure to the most critical pollutants potentially emitted by the incineration processes (heavy metals and dioxins).

10. Can you provide the approximate or range of costs on an annual basis to conduct your surveillance programs?
    The costs of our surveillance programs include, among others, personal costs for a permanent team comprising experts from several fields (chemistry, toxicology, epidemiology, statistics, sociology, medicine, environmental sciences) as well as laboratory and field technicians; analytical costs (clinical and chemical analysis); and field work costs (samples collection and questionnaires administration)

11. Are there any significant difficulties/obstacles that you encountered in carrying out your environmental surveillance activities?
    Collection of biological samples, mainly those using invasive techniques, as it is the case of blood collection, in particular when subjects are children.

12. Has the public opinion of incineration facilities in Portugal been impacted by the results/undertaking of your surveillance activities?
    In the first years, when incinerators were installed or updated, the answer is yes. People wanted to know what was going on in relation to their particular concerns. Nowadays, our results (which suggest that incinerators are under effective control) understandably do not impact significantly in the public opinion. I think that it is because good news are not news.

Other Activities

13. Are you aware of any further environmental surveillance programs in your country, or in other countries, initiated by the operation of incinerators? If so, can you elaborate on them or provide contact information for someone more familiar with them?

    In relation to both MWIs (near Lisbon and in Madeira Island), the environmental surveillance programs are developed by several institutions, each of them being responsible for a different component or a different set of monitoring activities. For example, related with the two above mentioned incinerators, monitoring of air quality is under the responsibility of IDAD, a scientific and technical non-profit Association, which has the following contact:

    IDAD - Instituto do Ambiente e Desenvolvimento
    Campus Universitário de Santiago
    3810-193 Aveiro
    Portugal
    tel. +351.234.400.800 ext. interna (UA) 12100
    fax. +351.234.382.876
    e.mail. sec@idad.ua.pt

14. Do you believe that the environmental surveillance programs that are currently in place are adequate to ensure the protection of public health and the environment? If not, how could they be improved?

    I think they are, mainly those involving human biomonitoring in exposed and control populations. They give the best measure of the real human exposure and provide the only mean to relate human exposure with potential associated adverse health effects.

15. We understand you are involved with the European Union Human Biomonitoring Network and Pilot Project Activities. Can you provide any details on the goals/logistics of the program?

    All information on the work already done within the ambit of the European Union Human Biomonitoring Network and Pilot Project Activities is available in: http://www.eu-humanbiomonitoring.org/. A new proposal is now being prepared. Understandably I cannot provide yet any detail on it.

    Has any environmental surveillance surrounding incineration facilities occurred as a result of this program?

    Not to my knowledge. In Portugal all incineration facilities have their own environmental surveillance program.

Comments/Questions/Suggestions

No comments, questions or suggestions.

J.L. Domingo, Laboratory of Toxicology and Environmental Health, Rovira i Virgili University, Spain - Correspondence

Questionnaire for Dr. J.L. Domingo – Returned in Writing November 4, 2008

General Questions

1. How long have you been involved in environmental and/or human health surveillance programs?

I am involved in human health surveillance programs since approximately 20 years ago. Moreover, since 1995, more specifically I am involved in programs related with the environmental impact and human health risks of the emissions of toxic pollutants by incinerators (municipal and hazardous).

Government

To your knowledge,

2. At what level of government are municipal waste incinerators (MWIs) regulated in your country? What branch/department of the government is responsible for MWI regulations?

   They are quite regulated by our Autonomous Government (Catalonia).The only Department directly responsible is the Environment Department. Not the Health Department. There is a specific organism in the Environment Department, called the Agency of Waste, who is in charge of all the issues concerning the facilities.

3. Are environmental surveillance programs a regulatory requirement for MWIs in your country?

   Catalonia (Spain) is a rather small country with 7.4 million people. There are 6 MSWIs in the territory, and only one HWI, which in addition, it is the only one in Spain. There are not special requirements concerning MSWIs, although most facilities in a certain moment have performed some kind of studies to assess their impact on environment and health.

   In contrast, the only HWI is much more controlled. There is a specific surveillance program for that facility. It is due to the concern the construction of that plant raised on the general population when the Government decided to built the HWI.

4. If yes, what components are required to form a part of such environmental surveillance programs?

   Most studies (volunteer for MSWIs, not volunteer for the HWI) have implied measurements of heavy metals, and dioxins and furans (PCDD/Fs) in samples of environmental matrices (air, soil, vegetation) collected near the facilities.
   The surveillance program for the HWI includes also measurements of the levels of metals and PCDD/Fs in samples of biological tissues belonging to individuals living in the vicinity of the incinerator. Thus, for example blood and hair are used for metals, or human milk and plasma for PCDD/Fs. For human health risk assessment, which is a key issue in the surveillance program, the dietary intake of the pollutants emitted by the incinerator (metals and PCDD/Fs) is also estimated.

Personal Research Activities

5. Who are the stakeholders in your surveillance programs (i.e. government, industry, etc.)?

   It depends. For example, for the MSWIs, both government and the industry (the same companies involved in the management of the facilities). For the HWI, the program depends only on the public administration.

6. What is the general scope of your surveillance activities?

   As above commented, our studies are mainly focused on detecting any potential health risks due to the emissions of toxic substances by the facilities. We have designed a complete surveillance program, which covers both environmental and biological measurements, which can give to us all necessary data for risk assessment.

7. Have all your results been published in the primary literature, and if not, what information on unpublished studies can you provide us?

   YES, absolutely. For us, to publish the results of our surveillance programs in international scientific journals is quite essential. It is the only way to consolidate our scientific credibility in the public opinion, which is here in Spain quite insinuating to this kind of facilities. Therefore, we think it is basic those programs are established.

   We have published a lot of papers on incinerators and human health. You can click my name (Domingo JL) in SCOPUS, MEDLINE, etc, and you will find the list of all my papers.

   We also prepare reports for the government and/or managers of the facilities. However, for us this is less relevant than the scientific publications due to its more limited diffusion.

8. Do you follow any particular best practices and if so, have these been publicly documented or published?

   The European Union, the US EPA, the WHO, etc. do not have elaborated any general regulations concerning surveillance programs for incinerators (municipal, hazardous and medical). Therefore, I myself -with my colleagues- have been the only responsible of designing the protocols of our surveillance programs, which have been subsequently approved by the government, or accepted by the managers of the facilities.

9. What have been the outcomes of your studies? Have they provided useful, measurable results?

   Yes. There is not any doubt that performing those studies has meant a significant decrease in the popular pressure against incinerators. In Spain, Universities are placed in a relevant position concerning the ranking of credibility. People trust in our studies, which on the other hand, are performed by us with an absolute independence of the financial support.

Other Activities

10. Are you aware of any further environmental surveillance programs in your country, or in other countries, initiated by the operation of incinerators? If so, can you elaborate on them or provide contact information for someone more familiar with them?

    No. According to the most used database, in recent years our group has been the most active in this kind of studies, not only in Catalonia and Spain, but also in Europe and America.

    Although some people in Spain and over the world, has performed a number of studies in certain moments, these can not be considered as belonging to real surveillance programs.

11. Do you know the approximate or range of costs on an annual basis to conduct these programs?

It depends very much on the extension of the study, and if it includes only environmental samples or also biological tissues. Therefore, the rank is quite wide.

Tentatively, I could tell you that a rather elemental study can mean about 36,000 Euros per year, while a very complete study can cost 120,000 Euros per year. However, this is only guidance.

12. Are you familiar with the European Union Human Biomonitoring Network and Pilot Project Activities? If yes, are you involved in it and if so, what is your involvement? Can you provide any details on the goals/logistics of the program?

    I know the program, but I am not involved in it.

<u>Comments/Questions/Suggestions</u>

According to my particular/personal, but very long experience, I would recommend establishing a surveillance program, which should be already initiated during the construction of the facility. Thus, the "background" results might be subsequently used to determine the temporal trends in the levels of emitted pollutants and on human health risks.

Absolutely important can be also (I do suggest it) to create a Commission to follow the results, which includes community leaders and subjects living in the area under potential direct influence of the emissions of the facility.

Greet Schoeters, VITO, Belgium - Correspondence

From: Schoeters Greet [mailto:greet.schoeters@vito.be]
Sent: Sunday, December 07, 2008 5:27 AM
To: Morin, Mathieu
Cc: Ollson, Christopher
Subject: RE: Phone Call Summary - Dec. 5th 2008

Dear Mathieu

This looks fine
best regards
Greet Schoeters
Project Manager Environmental Risk and Health -VITO
Professor, Department of Biomedical Sciences, University of Antwerp
President of European Society for Toxicology in Vitro
www.estiv.org
Address:
VITO (Flemish Institute for Technological Research)
Boeretang 200 , 2400- Mol
Belgium
tel: 014/335200
fax:014/580523
greet.schoeters@vito.be

Van: Morin, Mathieu [mailto:Mathieu.Morin@JacquesWhitford.com]
Verzonden: vr 5/12/2008 17:52
Aan: Schoeters Greet
CC: Ollson, Christopher
Onderwerp: Phone Call Summary - Dec. 5th 2008

Dear Dr. Schoeters,

Thank you kindly for your time and assistance on the telephone today. Your knowledge will be very valuable to our review.

I would appreciate if you could confirm for me that you provided the following information:

- You have been involved in the field of human biomonitoring for approximately 10 years.
- To your knowledge, incineration facilities are regulated at the stack (emissions), however facilities are not required by law to do any environmental surveillance or monitoring. Incinerators in Belgium are required to meet the regulations of the European Directive, and environmental legislation is established at the regional level (in your case, the Flemish public administration).
- The Flemish administration began supporting a human biomonitoring program to respond to public concern over the impact of industry on public health (incineration facilities representing one component of the program), and where to site industrial facilities. Your studies are as a result funded by the public administration.

- All methods and results are published on your study group's website, and you try to publish results in the scientific literature when possible. Publishing results aids in reassuring the public of the integrity of the studies and helps ease public concern.

- The general outcomes of your studies are that it is difficult to make a direct link between the source of pollution and pollutant levels in the human body. Residents surrounding eight (8) incinerators were studied and in general, no increased levels of the pollutants studied were found but exceptions exist were historical contamination is present from older incineration facilities.

- Your current work focuses on human biomonitoring of hot spots where contamination might exist, and a very general estimate for the cost of such a program would be around 600,000 Euros.

If any of the above is incorrect or inaccurate, please advise.

Once again, thank you for your time and assistance,

Regards,

Mathieu Morin, M.Env.Sc.
Study Team Member

Laura Green, Cambridge Environmental, United States – Correspondence

From: green [mailto:Green@CambridgeEnvironmental.com]
Sent: Monday, December 29, 2008 7:18 PM
To: Morin, Mathieu
Subject: RE: Energy-From-Waste and Environmental Surveillance

Yes, your notes are fine, and you may list me as you wish.
Best regards, and happy New Year.

Laura Green, Ph.D., D.A.B.T.
Senior Scientist and President
Cambridge Environmental Inc.
58 Charles Street
Cambridge MA
02141
telephone: 617 - 225 - 0810 x25
fax: 617 - 225 - 0813
www.CambridgeEnvironmental.com
Green@CambridgeEnvironmental.com

From: Morin, Mathieu
Sent: Friday, December 05, 2008 5:09 PM
To: 'Laura Green'
Cc: Ollson, Christopher; Henderson, Sarah
Subject: RE: Energy-From-Waste and Environmental Surveillance

Hi Laura,

Thanks for your time on the phone earlier today. The information and the leads are very much appreciated.
Should you happen to remember the name of the contact at the EPA that you couldn't remember, please feel free to email me later on.

The following are the minutes we recorded from the conversation:
- You have been involved in EFW projects for ~25 years.
- The regulatory framework in the U.S. has had a complex history. Currently, based on Best Available Control Technology, the federal government (EPA) has set regulatory emissions levels for pollutant levels at the stack. In some States, the levels are more strict based on public or political pressure.
- The facilities themselves don't conduct environmental monitoring because it is assumed that if they are meeting the prescribed emissions limits, then they are in effect being protective of the environment. There is little incentive for these facilities to go above and beyond this duty.
- Newer facilities emit such small levels that it would be difficult to design a sampling program today that could actually find a link between levels in the environment and the facility itself.
- Recommendation to speak with Steve Zemba, Nick Themelis, David Minott, and Ted Michaels.

If any of the above is inaccurate, please let me know.
Thanks again!
Mathieu

Dr. Goran Krstic, Fraser Health Authority, British Columbia, Canada – Correspondence

From: Krstic, Goran [mailto:Goran.Krstic@fraserhealth.ca]
Sent: Friday, January 09, 2009 12:55 PM
To: Morin, Mathieu
Cc: Stewart Lockwood; Shaw, Ken
Subject: RE: Conference Call Minutes-9Jan2009

Thanks Mathieu,

I made some minor corrections in this summary (see below within the text in **red**).

Best regards
Goran

Dr. Goran Krstic, B.Sc., Ph.D., R.P.Bio.
Human Health Risk Assessment Specialist

Fraser Health Authority
Environmental Health Services
537 Carnarvon Street
New Westminster, BC
V3L 1C2
Tel.: (604) 777-6728
Fax: (604) 525-3608
e-Mail: Goran.Krstic@fraserhealth.ca
Webpage: www.fraserhealth.ca

From: Morin, Mathieu [mailto:Mathieu.Morin@JacquesWhitford.com]
Sent: Thursday, January 08, 2009 12:29 PM
To: Krstic, Goran; Stewart Lockwood
Cc: Ollson, Christopher
Subject: Conference Call Minutes

Hi Goran, Stewart,

Thanks again for your time on the phone earlier. I believe we got the information we were looking for. I'm sorry if I wasn't more helpful on the details of the risk assessment – if either of you have any more questions on the process, I'm sure I can get you the answers you're looking for.

For the purpose of our report, Sarah and I took some notes during the call, and I was hoping that you could confirm that the following is an accurate summary of the call, or let me know if any corrections are necessary.

- The facility has been in operation for over 20 years.
- The facility conducts stack monitoring, and there is a valley-wide air quality monitoring network in place.
- When stack monitoring highlights an issue with the facility, the facility is shut-down and corrected or another appropriate measure is taken.
- To your knowledge, Fraser Health Authority has not conducted any health studies or surveillance activities at or around the facility in the recent past and there are no current plans to do so.
- With traffic in the valley, as well as cement manufacturing facilities and other industry, the air quality monitoring network is generally not capable of detecting whether or not the incineration facility is operating.

- When the facility was constructed, the Environmental Management Act was still in development, and only a limited number of public meetings were held. Generally, there is little public awareness to the existence of the facility. Recent talk and rumors of building another facility have reignited concern and public opposition.
- General air quality in the valley is of greater concern than the impact of point sources. Examples of these concerns might include
    - The impact of traffic which can overwhelm background levels and sources of pollutants
    - {delete ~~Indoor air quality, which can be managed and corrected. Compared to indoor air quality, there is very little that can be done to reduce levels of pollutants in ambient air.~~} We are focusing more on indoor air interventions because of the greater exposure time, and often higher concentrations of air contaminants, and a greater potential to reduce these exposures.
    - There is a good deal of agricultural areas in the valley, leading to a large amount of ammonia in the air. This ammonia can interact with other air pollutants such as NOx and SO2 to produce ground level ozone

Thanks again for your help and I hope we can continue to share information into the future,
Mathieu

Mathieu Morin, M.Env.Sc., EIT
Jacques Whitford Limited
3430 South Service Road, Suite 203
Burlington, ON, L7N3T9
Tel: (905) 631-8684
Mathieu.Morin@JacquesWhitford.com

Chris Allan, Metro Vancouver, British Columbia, Canada – Correspondence

From: Chris Allan [mailto:Chris.Allan@metrovancouver.org]
Sent: Tuesday, January 13, 2009 5:52 PM
To: Morin, Mathieu
Subject: RE: Phone Call Minutes - Friday, Jan 9, 2009

Hi Mathieu,

I have edited the comments below to reflect our situation in Metro Vancouver. Hope this helps your efforts back east.

Regards,

Chris Allan, P.Eng.
Senior Engineer
Metro Vancouver – Engineering & Construction Dept.
Tel: 604-432-6468 Fax: 604-451-6180
e-mail: Chris.Allan@MetroVancouver.org

From: Morin, Mathieu [mailto:Mathieu.Morin@JacquesWhitford.com]
Sent: Monday, January 12, 2009 7:44 AM
To: Chris Allan
Cc: Ollson, Christopher
Subject: Phone Call Minutes - Friday, Jan 9, 2009

Hi Chris,

Thanks again for your time on the phone on Friday. I really appreciate all the knowledge and information you were able to share with me.

As mentioned in the call, here are the minutes representing the notes that I took and the information we'd like to use in the report. If you could have a look over them and confirm their accuracy, that would be much appreciated.

- The Metro Vancouver Waste-to-Energy Facility (WTEF) operates under emission standards established in the late 1980's and currently set out in the 1995 Solid Waste Management Plan (SWMP). The Provincial governments Emission Criteria for Municipal Solid Waste Incinerators was published in 1991. Currently the WTEF has a more stringent standard for sulphur dioxide.
- NO_x, CO, SO_2, and opacity are monitored continuously and reported monthly to the BC Ministry of the Environment (MoE).
- Manual stack testing is conducted three times per year (the regulation requires this to be done at the direction of the Province but is typically once per year in other industries). Triplicate tests are conducted for each sampling event, on each of 3 lines. Stack testing is conducted for PM, NOx, CO, SO_2, HF, HCl, total hydrocarbons, and metals (Hg, Cd, Pb in particular).
- There is no regulatory frequency requirement for the sampling of dioxins except at MoE's request. This request has never been made to Metro Vancouver in the past eight years or more. Regardless, the facility tests the stack for dioxins every 2 years, as per the CCME recommendations for facilities with established emissions.
- Other organics are also tested occasionally to ensure that these values remain well below requirements (PAHs, PCBs, HCB, etc.)

- There is zero liquid discharge at the site which was implemented in 2001. Occasional releases may occur if upset conditions are present at the plant which go beyond the on-site storage capacity, occurring on average once per year. Testing as required by permit is conducted prior to any such discharge to the sewer.
- If an exceedance is noted during continuous monitoring, it is noted immediately as data is available in real-time. The problem is first sourced. If the problem is combustion related, combustion parameters are adjusted to deal with the exceedance in real-time. If the problem is not combustion related, the unit responsible for the exceedance is shut down and fixed.
- If an exceedance is noted during manual testing, a duplicate retest would be issued to ensure that the exceedance was not caused by laboratory or sampling error. Contamination and errors (lab or sampling) are potentially an issue with the low levels of some parameters being tested such as dioxins, mercury and particulate.
- Any exceedances would be reported to the Ministry, who would then decide if there is reason for concern based on the information available to them.
- MoE has not expressed any concerns with the operation of the WTEF.
- In the 1980's, the facility conducted an environmental baseline consisting of air, soil and vegetation samples.
- After facility operation commenced, this environmental monitoring program was continued for several years. The results of the program did not identify any impact to the environment caused by the operation of the facility.
- After these results were obtained, Metro Vancouver scaled back the monitoring program and limited it to ambient air monitoring on the basis that there was no measurable impact and no evidence of the plant's operation in the ambient air quality. Originally, this consisted of a number of continuous air samplers surrounding the facility and a mobile air unit that was operated in various locations around the facility. After further years of similar results in which no impact was observed as a result of the facility, the air monitoring program was scaled back to 3 continuous samplers which have since been integrated into a regional air quality monitoring network which still operates. As a part of this network, these monitors are operated by Metro Vancouver, but remain in positions that would be sensitive to emissions from the facility.
- No emissions have been found in the ambient environment and attributed to the facility to date.
- Human health studies have not been broached by the facility or Metro Vancouver as the results environmental monitoring programs have never indicated a need for such a study as the operation is not detected in the ambient environment.
- With regards to public awareness and perception the WTEF maintains a very low profile. The majority of citizens don't know that the facility exists. Among those who come to the facility to see its operations, the most common comment received is "Why aren't we doing more of this?".
- There are some in the region who are against waste-to-energy but this will likely always be the case.

Hope you had a great weekend,
Mathieu

Mathieu Morin, M.Env.Sc., EIT
Jacques Whitford now Stantec
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Ken Reid, Metro Vancouver, British Columbia, Canada - Correspondence

From: Ken Reid [mailto:Ken.Reid@metrovancouver.org]
Sent: Tuesday, January 13, 2009 6:32 PM
To: Morin, Mathieu
Subject: RE: HRA Studies for DY

Mathieu,
Attached are two papers that were presented at the Air & Waste Management Association's Annual Meeting and Exhibition in Denver, Colarado, June 13 – 18, 1993.

I also have 2 other reports from 1992 that I will try to send you tomorrow which give a bit more detail.

In summary, though, it was found, following some special ambient air quality monitoring from 1987 to 1990 that:

- Ambient air quality in the vicinity of the incinerator is generally similar to other areas of Metro Vancouver
- Maximum air quality readings in the vicinity of the incinerator are generally lower than those recorded for the rest of Metro Vancouver
- Ambient air quality trends (over the study period) indicate no change or a slight decrease in both maximum and average concentrations of specific contaminants. This trend is similar to that noticed throughout the rest of Metro Vancouver
- Metals concentrations in suspended particulates are very low or are below detectable limits, and are similar to values measured in other parts of Metro Vancouver.
- Mobile monitoring results parallel those from the fixed stations with slight variations due to localized site specific influences.

In about 1994 all but 2 monitoring sites were shut down, and these 2 became long-term stations within the network. These 2 sites have not indicated any noticeable impact attributed to the Burnaby facility. In fact up to 2006:

- The trends in CACs at these 2 sites are similar to those noticed for the network as a whole
- The average annual values at these 2 sites are the same as or lower than to those noted for the network as a whole
- There continues to be no major measurable difference in average annual CACs between these 2 sites and the rest of the monitoring network

A recent description of our air quality monitoring network can be found here:
http://www.metrovancouver.org/about/publications/Publications/2007LFV-AirQualityReport.pdf

The two stations that remain are T18 – Burnaby South and T13 – North Delta.

Hope this helps.

Ken Reid, M.Sc.
Air Quality Planner
Policy and Planning Department
Metro Vancouver,
604.436.6878
604.436.6701 (Fax.)
ken.reid@metrovancouver.org

Ellen Lee, Health Canada – Correspondence

-----Original Message-----
From: Ellen Lee [mailto:ellen_lee@hc-sc.gc.ca]
Sent: Tuesday, December 09, 2008 10:08 AM
To: Ollson, Christopher
Subject: Re: Canadian Health Measures Survey (CHMS)

Hi Chris,

I hope all is well. Nice to hear from you!

Clarington was indeed one of the 15 sites that was sampled in Cycle 1 (2007-2009) of the CHMS. However, due to the sampling frame of the survey, results cannot be reported by region. Rather, the CHMS is a nationally-representative survey that represents 97% of the Canadian population and therefore Statistics Canada and Health Canada will be reporting results on a nation-wide basis after compiling the data from all 15 sites. Please see the following list of sites sampled in Cycle 1:

- Clarington, Ontario
- Montérégie, Quebec
- Moncton, New Brunswick
- Toronto (North York), Ontario
- Montréal, Quebec
- Kitchener–Waterloo, Ontario
- Vancouver, British Columbia
- Red Deer, Alberta
- Williams Lake and Quesnel, British Columbia
- Edmonton, Alberta
- South Mauricie, Quebec
- Québec, Quebec
- Northumberland County, Ontario
- St. Catharines–Niagara, Ontario
- Toronto (Don Valley), Ontario

The sampling sites in Cycle 1 were selected based a sampling frame designed by Statistics Canada. In short, the 15 sites were selected from a total of 257 potential collection sites with a population of at least 10 000 and a maximum respondent travel distance of up to 100 km. The collection sites were stratified by the five regions (e.g. British Columbia, the Prairies, Ontario, Quebec, and the Atlantic Provinces) to ensure representative distribution of the sample across the country. The sites were then sampled systematically with the probability of selection proportional to the size of the population.

In Cycle 2, a similar sampling frame will be used. It is expected that sites from Cycle to Cycle will differ, although there is of course, a possibility that Clarington could be selected again. Again, this may not be helpful in the sense that results are representative of Canadians, rather than reported by residents living in a particular area.

We have not yet begun planning for Cycle 3 (2011-2013), but we have raised the possibility of starting to examine/report data specifically for regions. The

municipalities and/or provinces that are interested in this option would be welcome to provide input as well as 'sample buy-ins' (e.g.
funds) for the third Cycle. However, we have not directly addressed this yet as planning for Cycle 3 will be underway starting early next year.

I hope this has been helpful? If you have any further questions, feel free to contact me.

Ellen

Andrew Neill, Ontario Ministry of the Environment – Correspondence

From: Neill, Andrew (ENE)
To: McKay, Jim
Cc: Gebrezghi, Tesfaye (ENE)
Sent: Mon Dec 22 17:27:48 2008
Subject:
Hi Jim,

I have compiled PDF files of the CofAs and notices that contain provisions regarding monitoring and testing for the 5 EFW facilities identified in Ontario (Algonquin Power, Liberty Energy, Enquest, 2132656 Ontario Inc. (Remasco), and Lafarge). The original CofA for Algonquin Power will follow in 4 parts, as the attachment is too large for a single e-mail.

If you have any questions regarding the attached, please contact me.

Andrew Neill, P.Eng.
Senior Waste Engineer
Ministry of the Environment
Environmental Assessment and Approvals Branch
Waste Unit
Phone: (416) 314-8438
Fax: (416) 314-8452
E-Mail: andrew.neill@ontario.ca

From: McKay, Jim [mailto:Jim.McKay@JacquesWhitford.com]
Sent: December 11, 2008 10:22 AM
To: Gebrezghi, Tesfaye (ENE)
Cc: Payne, David; Battarino, Gavin (ENE)
Subject: Durham/York - Environmental Surveillance Study

Tes,

Under the direction of Durham Region Council, Jacques Whitford is conducting a review of best practices of environmental surveillance at Energy-from-Waste facilities around the world as part of the Durham/York EFW project. Given this, the practices currently undertaken here in Ontario are particularly relevant. We would appreciate it if you could provide us with a list of facilities in Ontario which include the thermal treatment of waste materials where there are conditions in the CofA for environmental monitoring of some sort. If you could provide a copy of the CofA for each of these facilities outlining any and all monitoring requirements and procedures for that facility, whether they be related to emissions released from the stack or contaminant levels in the surrounding environment.

If you have any questions, or would like to discuss the above request further, please call.

Thanks,
Jim

Jim McKay, B.A.
Leader, Central Canada Waste Services Group

Jacques Whitford Limited
3430 South Service Road, Unit 203
Burlington, ON L7N 3T9

Canada
Tel 1: 905-631-3910
Tel 2: 905-631-8684
Cell: 905-467-9897
Fax: 905-631-8960
Email: Jim.McKay@jacqueswhitford.com

Dr. Matthew Lorber, United States Environmental Protection Agency – Correspondence

-----Original Message-----
From: Lorber.Matthew@epamail.epa.gov [mailto:Lorber.Matthew@epamail.epa.gov]
Sent: Thursday, December 18, 2008 1:52 PM
To: Morin, Mathieu
Cc: Ollson, Christopher
Subject: Re: Energy-From-Waste and Environmental Surveillance

Mathieu - sorry I'm not much help with regard to regulatory framework. Being in EPA's Office of Research and Development, I just haven't focused too much on regulations. You may want to click your way around our Air Toxics Website for some info: http://www.epa.gov/ttn/atw/. I was very much involved in the mid-1990s on evaluations of the Columbus Municipal Solid Waste incinerator in Columbus, Ohio. The focus there was on dioxin. I've attached two studies on that site. Finally, I think if you are interested in surveillance around incinerators, you may want to see if the Navy Environmental Health Center will provide you with some reports from their investigation in Atsugi, Japan. I published a few abstracts on that, which I'll attach also, but you should get in touch with: Vera Wang wangv@nehc.med.navy.mil, or Yvonne Walker walkery@nehc.med.navy.mil. I don't know why I don't have their phone numbers. If you say you have contacted them on my recommendation, they might be more willing to share their info.

Hope the attachments help.

Matt

(See attached file: COLUMBUSINC.PDF)(See attached file: 2-481.PDF)(See attached file: 3-289.PDF)(See attached file: COLPAPER.PDF)(See attached file: ISC3VALIDATION.PDF)

From: "Morin, Mathieu" <Mathieu.Morin@JacquesWhitford.com>

To: Matthew Lorber/DC/USEPA/US@EPA

Cc: "Ollson, Christopher" <Christopher.Ollson@JacquesWhitford.com>

Date: 12/11/2008 11:02 AM

Subject: Energy-From-Waste and Environmental Surveillance

Dear Dr. Lorber,

Steve Zemba of Cambridge Environmental suggested that I get in touch with you regarding a review we are currently conducting in Durham Region, Ontario, just east of Toronto. Our firm is currently involved in the planning of an Energy-From-Waste facility in the region. As a component of the process, we are conducting a review of environmental surveillance practices in the Energy-From-Waste industry. Our working definition of environmental surveillance includes elements such as human biomonitoring and ambient environmental monitoring.

Specifically, we are interested in understanding the regulatory framework for energy-from-waste facilities in the United States, and the extent to which environmental surveillance takes place around these facilities (as a legislative requirement or as a voluntary program).

We’re hoping you might be able to assist us in this regard. I was wondering if perhaps we could schedule a time to speak on the phone? I am freely available most of next week.

We appreciate any assistance you could provide in this regard, Sincerely, Mathieu Morin, M.Env.Sc., EIT

Jacques Whitford Limited
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Burlington, ON, L7N3T9
Tel: (905) 631-8684
Mathieu.Morin@JacquesWhitford.com

APPENDIX H

Study Protocol

STUDY PROTOCOL

Review of International Best Practices of Environmental Surveillence for Energy-From-Waste Facilities

PROJECT NO. 1009497.06

PROJECT NO. 1009497.06

ON

Draft Study Protocol for the Review of International Best Practices of Environmental Surveillance for Energy-From-Waste Facilities

November 3, 2008

Jacques Whitford
3430 South Service Road, Suite 203
Burlington, Ontario
L7N 3T9

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Fax: 905-631-8960

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STUDY PROTOCOL

1.0 OVERVIEW

Jacques Whitford Limited has been retained by Durham Region and York Region to conduct a review of international current practices of environmental surveillance being undertaken at Energy-From-Waste (EFW) facilities. This project is being done in conjunction with the Durham/York Residual Waste Study that is focused on obtaining environmental assessment approval to construct an EFW facility in the Municipality of Clarington. Ultimately, this study will provide a consultant's recommendation on the appropriate level of environmental surveillance that should be considered as a component of the life cycle of the facility to be built.

The study was specifically designed to address a motion by Councillor Jordan made at the Durham Regional Council meeting on Wednesday, May 28th, 2008, which was carried and states in part:

> *"g) i) THAT staff review the best practices of environmental monitoring programs which include environmental surveillance, health surveys, biological monitoring, health studies, and any other pertinent studies as determined through the review and consultation regarding environmental monitoring programs; and*
>
> *ii) THAT an environmental monitoring program be developed based on best practices which will provide baseline information and ongoing studies during the life cycle of the facility";*

A second motion by Councillor Ryan was then carried, which directed that the foregoing motion be referred to the Joint Waste Management Group (JWMG) meeting with a report directly back to Durham Regional Council.

Environmental surveillance is an all-encompassing term, while human health and environmental monitoring are considered components of environmental surveillance programs. Human health monitoring, can include programs such as health surveys, health studies and biological monitoring (i.e. human biomonitoring), which typically involves the collection of human samples (i.e. blood, urine, etc.) for chemicals and associated by-products. Environmental monitoring, on the other hand, typically involves the sampling of environmental media; such as soil, air, water or biota (*e.g.*, fish, small mammals, and vegetation). This study will cover a review of environmental surveillance and includes both environmental and human health monitoring.

At the time of writing this study protocol report, Clarington 01 had been selected as the preferred site for the EFW facility. However, no vendor or specific technology has been selected for implementation. This is not considered a study-limiting factor, as this study will focus on the best practices of environmental surveillance programs associated with any number of different energy-from-waste facilities, as well as other incineration-based facilities, as they may be of relevance. Non-incineration based industries will not be included in the review, in order to place both a reasonable limit on its scope and maximize the ability of the reviewers to form scientifically sound conclusions based on the results.

Figure 1-1 provides a general outline and overview of the study that will be conducted in two stages. Stage 1, the subject of this document, is to create a Study Protocol that will guide the conduct of the study team throughout the project and will ensure that scientifically sound and defensible methods for the various tasks are followed. Once the Study Protocol has been reviewed by an independent third party peer reviewer and subsequently finalized, then Stage 2 of the project will consist of undertaking its implementation.

Background information on environmental surveillance programs can be collected immediately and will provide a solid foundation for the reviewers on which to build their review. Possessing this background knowledge will also aid in informing the reviewers prior to conducting external contact interviews, such that the reviewers can maximize their ability to engage the interviewees and retrieve information relevant to the study objectives.

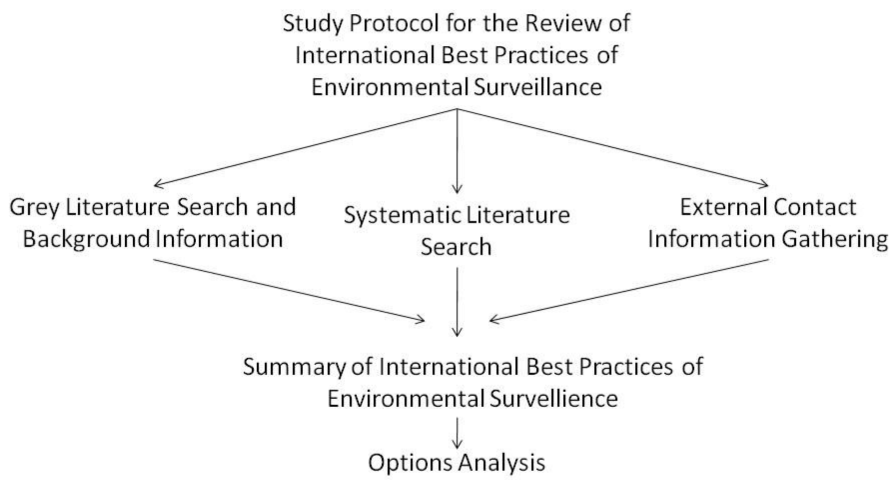

Figure 1-1 General Overview of Study Process

The systematic review of the scientific literature consists primarily of three separate elements – the literature search strategy, the inclusion/exclusion criteria for the analysis of the search results, and the framework for documenting, evaluating and interpreting results. These three elements combined provide a transparent framework to support the consistent review of articles. Likewise, the protocol for securing information from external contacts ensures that consistent information is obtained without the need for repeated inquiries.

Also included in the Study Protocol are initial thoughts on how the Options Analysis may be undertaken, composition and qualifications of the Study Team, and an overview of the schedule and deliverables.

2.0 DEFINITION OF KEY STUDY TERMINOLOGY

In keeping with the mandate of this component of the project, a review of international environmental surveillance programs will be carried out. The review will focus on programs such as environmental surveillance, and its components – biomonitoring, studies and surveys.

The current report does not seek to identify all potential health concerns that may be related to living within proximity to an EFW facility. Rather the Site Specific Human Health and Ecological Risk Assessment that is being conducted as a component study to the environmental assessment will ensure that no adverse health impacts are predicted as a result of emissions from the facility.

This document will describe the Study Protocol that will be used to: search and locate the relevant scientific literature, establish criteria for including/excluding published studies and obtain information from other sources such as the internet and individual contacts – relating to the above mentioned studies in conjunction with EFW facilities. The following sections serve to introduce and define each of the terms that will be used in this study.

2.1 Environmental Surveillance and Monitoring

Surveillance is a continuous and systematic process of collection, analysis, interpretation, and dissemination of descriptive information for monitoring health problems (Rothman and Greenland, 1998). *Monitoring* is the intermittent performance and analysis of routine measurements, aimed at detecting changes in the environment or health status of the population (Last, 2000). Surveillance is distinguished from monitoring by the fact that it is continuous and ongoing, whereas monitoring is intermittent or episodic.

The following sections further define the concepts of environmental surveillance, biological monitoring, surveys, and studies. The hierarchy of environmental surveillance is provided in Figure 2-1.

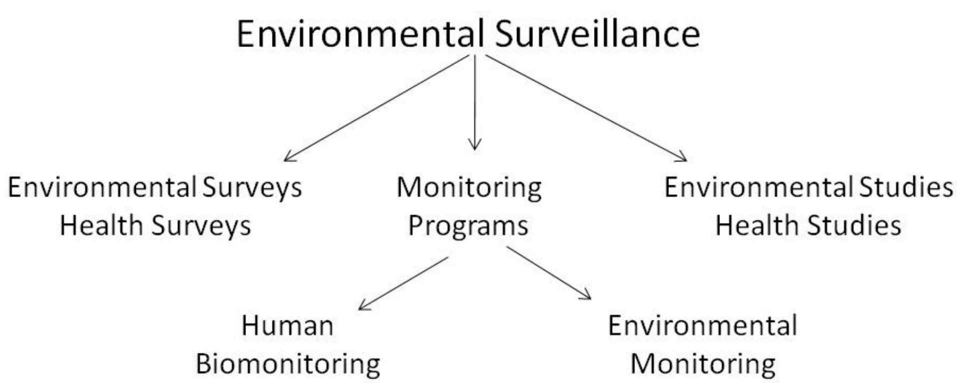

FIGURE 2-1 ENVIRONMENTAL SURVEILLANCE HIERACHY

2.1.1 Environmental Surveillance

Environmental surveillance is a broad topic under which a wide range of information can be collected on exposures based on emissions data, dispersion modeling, and the monitoring of air, water, soil, vegetation, fauna and humans. It can include various possible programs, such as biological (including human) monitoring, health studies and health surveys.

Environmental surveillance can be a useful tool in the overall life-cycle assessment of chemical-emitting facilities. As with any combustion process, chemicals emitted can be deposited over variable distances. Developments in pollution control technology have greatly reduced the amount of chemical emissions from EFW facilities; however some level of surveillance would be required to ensure that predictions made in the air modeling and risk assessment are valid upon commissioning of a facility.

2.1.2 Human Biomonitoring (Biological measures of Exposure)

Human biological monitoring, more commonly known as human biomonitoring (HBM), is the measurement of specific substances in the human body, usually through the analysis of blood, urine, breast milk and tissue samples (American Chemistry Council, 2005). Health Canada (2007a) defines biomonitoring as:

> *"the measurement of a chemical, the products it makes after it has broken down, or the products that might result from interactions in the body. These measurements are usually taken in blood and urine and sometimes in other tissues such as hair, saliva and breast milk"*.

This clarification is important because the "biological marker" may not be the chemical in the environment itself, but some product resulting from the body's interaction with the chemical.

Obtaining such samples may be intrusive and requires the consent of the sample donor. In addition, ethical approval and oversight are required for these activities, whether part of a research program or a public health non-research program (Reis, 2007).

2.1.3 Environmental Monitoring

Environmental monitoring is rather similar in nature to human biomonitoring, with the major difference between the two programs residing in the nature of the matrix under study – rather than collecting biological samples from humans, media include ecosystem components such as soil, water, air, vegetation and fauna (*e.g.,* fish, small mammals, and birds).

An example of environmental monitoring already in place for the Durham/York Residual Waste Study is the ambient air monitoring that has been occurring at the Courtice Road site for the past year (Jacques Whitford, 2008).

2.1.4 Health Surveys

Health surveys collect information from participants about their health, habits and life circumstances through a variety of means, including through interviews (conducted in person or over the phone), or by self-administered questionnaires (WHO, 2008). They are often used to provide information on the health status of communities and estimates of health determinants.

Health surveys are integral components of national programs such as the National Health and Nutrition Examination Survey (NHANES) in the United States, the Canadian Health Measures Survey (CHMS) (Health Canada, 2007a), and the Maternal-Infant Research on Environmental Chemicals (MIREC) project (Health Canada, 2007c). Programs such as NHANES have contributed to significant scientific findings such as the link between high levels of cholesterol and heart disease (NHANES, 2007).

2.1.5 Environmental Surveys

An environmental survey is the observational study of the ecosystem and its physical components through the use of scientific design and survey methodologies to evaluate potential stressors on the environment (UN FAO, 1990). These surveys are also often referred as biophysical surveys and do not involve sampling or sacrificing flora or fauna, rather they are observational.

These studies are particularly useful in understanding holistic interactions of ecosystems in areas that may be subject to environmental stressors.

2.1.6 Health Studies

The objective of a health study is to investigate a health concern using appropriate methods of discovery as governed by the nature of the concern. Health studies differ from surveillance and monitoring programs in that they seek to identify the relationship between individual characteristics and the occurrence of disease or outcome. The identification of the health concern or issue, however, may stem from the results of surveillance or monitoring programs. In the case of environmental health studies they are designed in a systematic way to scientifically explore and evaluate exposure-outcome relationships (ATSDR, 1996).

Health studies are typically retrospective in nature and there are major differences in the types of studies that can be done. The Agency for Toxic Substances and Disease Registry (ATSDR) of the Centers for Disease Control (CDC) in the United States separate environmental health studies into two types. Type 1 studies are often conducted to explore health concerns or potential exposures and determine the need for a more definitive study. Type 2 studies require a higher level of scientific rigor and often involve the use of case-control or the cohort approach (ATSDR, 1996).

3.0 SYSTEMATIC SCIENTIFIC LITERATURE REVIEW

3.1 Objectives

The objective of the systematic scientific literature review is to identify relevant English-language literature on the current practices employed in environmental surveillance programs initiated by EFW or incineration facilities around the world, with a publication date of January 1, 1990 or later. Pollution control technology has improved substantially over the preceding decade and this arbitrary cut-off date should ensure that studies identified during this period reflect current industrial technology while also allowing for recent long-term studies to be published in the scientific literature.

Guidance for the development of the article search and evaluation process has been outlined by the Cochrane Handbook for Systematic Reviews of Interventions (Cochrane Collaboration, 2008). The Cochrane Handbook is the standard for conducting information reviews in the health care and pharmaceutical industries. Cochrane reviews adhere to the principle that "science is cumulative" and by considering all the available evidence, decisions can be made that reflect the best science available. While the Cochrane review methodology may be immediately relevant to research questions in the health care industry, the applicability of the methodology is widespread because the key characteristics of the review process are universal. The Cochrane Handbook cites the five key characteristics of a systematic review as:

- A clearly stated set of objectives with pre-defined eligibility criteria for studies;
- An explicit, reproducible methodology;
- A systematic search that attempts to identify all studies that would meet the eligibility criteria;
- An assessment of the validity of the findings of the included studies, for example, through the assessment of the risk of bias; and,
- A systematic presentation, and synthesis, of the characteristics and findings of the included studies.

This scientific process and the ensuing systematic review will strive to adhere to these five key characteristics. This document will outline the steps taken to meet the first three characteristics, while the framework will be presented for the achievement of the final two.

A professional Health Sciences Information Specialist/Librarian, trained and practicing in the field of health sciences systematic review has been engaged for this project.

Overview of Systematic Scientific Literature Review ProcessFigure 3-1 provides an overview of the systematic literature review process. The search strategy, developed by a Health Sciences Information Specialist/Librarian in consultation with the Review Team, will be undertaken for the purposes of locating relevant studies for this report.

The following bibliographic databases will be searched: Ovid's Medline In-Process & Other Non-Indexed Citations, Medline and EMBASE; The United States National Library of Medicine's PubMed (limited to non-Medline items) and TOXLINE; Wiley's Cochrane Library; Thomson's BIOSIS Previews; and Cambridge Scientific's Environmental Science and Pollution Management. It is likely that a high degree of overlap will be encountered when searching all seven databases; however, this exhaustive search ensures a greater coverage of the potential scientific literature on the subject.

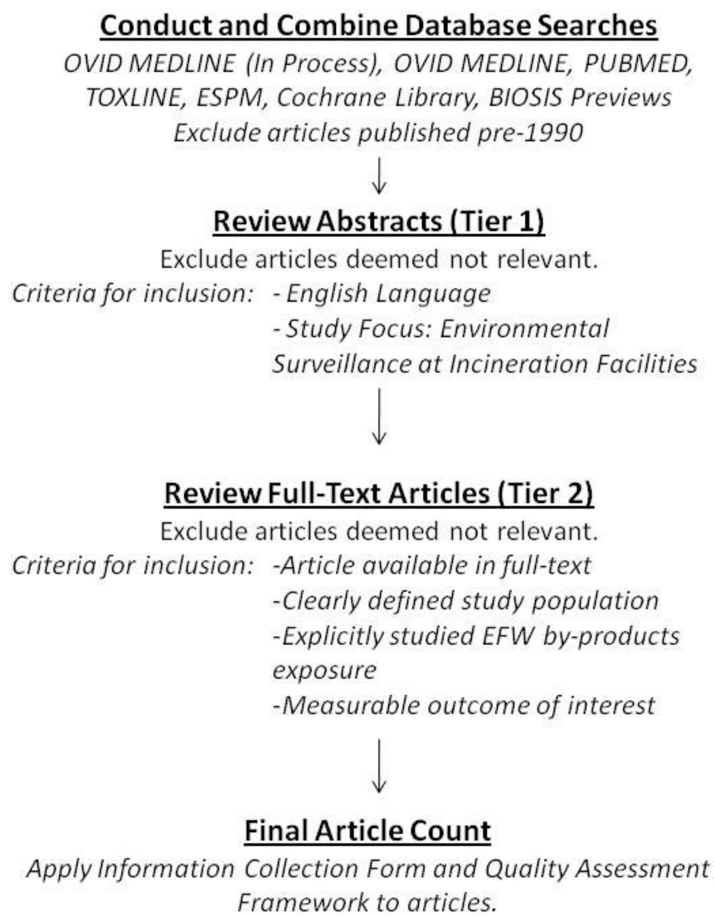

FIGURE 3-1 OVERVIEW OF THE SYSTEMATIC SCIENTIFIC LITERATURE SEARCH PROCESS

Appendix A outlines the proposed MEDLINE search strategy and logic. Searches will be limited from 1990-present. No language restrictions will be employed during database searching; however, only English language articles will ultimately be included in the review. Due to the fact that a large proportion of the indexed scientific literature is published in English, and of the delays associated with translation of international articles, it is felt that this language restriction will not significantly decrease the effectiveness of the review. As with any search strategy, every attempt was made to balance elements of comprehensiveness and relevance. For instance, increasing the comprehensiveness of a search is likely to reduce the general relevance of the search results (Cochrane Collaboration, 2008).

After the bibliographic records have been compiled, and any duplicate items have been eliminated, the titles/abstracts of all articles will be reviewed to assess their relevance to the review (Tier 1 Screening). Where abstracts are not available, relevance will be judged from the title of the article. Relevant criteria include:

- The study population is clearly defined and applicable: humans or environmental media;
- Exposure to EFW or incineration by-products was explicitly studied; and
- The outcome of interest was a human health, biological or environmental measure.

Two reviewers will independently screen the titles and abstracts for relevance using a predefined checklist of inclusion and exclusion criteria. Kappa statistics for inter-rater agreement will be calculated and reported. Any discrepancies between reviewers will be discussed until consensus is reached.

The articles which have passed initial title/abstract review will be obtained and reviewed in full-text form (Tier 2 Screening). If full-text articles cannot be obtained through achievable means, then they will be excluded from further review. Reference lists of full-text articles which meet inclusion criteria will also be reviewed to identify articles that were not identified via the initial systematic search. The final result of this process as well as the search for grey[1] literature will be a compilation of articles that satisfy the eligibility criteria outlined for review.

Due to the number of publications that the scientific literature search and grey literature search may identify, it will be imperative that the researchers use bibliographic software that will aid in the management of this information. For the purposes of this study, Reference Manager™ Version 11 will be used to keep track of the literature retrieved and to generate the final list of references for the Final Report. When the literature search has been conducted in the databases of interest, the retrieved references will be imported and consolidated into a master database in Reference Manager™. For literature that is not retrieved through an online database, the bibliographic information will be manually entered into the master database. Once all bibliographic information has been entered into the master database, Reference Manager™ can then be used to facilitate the removal of duplicates and to stratify references based on desired criteria.

In the review stages, Reference Manager™ will be useful in storing information relating to the inclusion and exclusion of studies. It will also facilitate an efficient dual reviewing process. Finally, Reference Manager™ can generate bibliographies in a number of different formats. This will aid in the compilation of a final bibliography of literature selected for the study.

[1] Grey Literature are open source materials that are not controlled by commercial publishing. These materials are usually produced by the government, academia, associations, business and industry, and included government publications, technical reports, newsletters, bulletins, white papers ...

3.2 Data Abstraction and Analysis

Once a study has passed through the exclusion/inclusion framework, and has been deemed acceptable for review, it will undergo a thorough analysis to extract the relevant information from the article.

Table 3-1 and Table 3-2 provide examples of study-specific information collection forms that will be used during the data and information abstraction of an article. The forms are designed to extract the information relevant to the objectives of the study. Once all the articles have been abstracted, the information can then be readily and easily compared as all articles are indexed in a common format. Different forms are used for human and environmental studies since the information extracted from each study will be different in each case. Where information, data or results are missing or unclear, the reviewers will attempt to contact the authors of the study for further information.

The next step will be to complete a quality assessment to identify the confidence that can be placed in the results and practices employed in each article found. A high degree of confidence in the results is essential to establish reliance on the conclusions of the review. The quality assessment framework to be used is founded on a combination of two systems: 1) that used by Dr. Lesbia Smith's epidemiological review of the human health effects of energy-from-waste facilities, commissioned by the Medical Officer of Health for the Region of Durham (2007) and 2) the use of the GRADE approach for grading quality of evidence as recommended by the Cochrane Handbook for Systematic Reviews of Interventions (2008). Each article under review will be assigned a quality level ranging from high to very low in each of four separate categories: study design, study/control group selection, sample collection and critical results analysis.

Since the purpose of this review is to identify best practices of environmental surveillance programs, it is essential that the focus of the quality assessment be on the practices employed by the researchers. The quality assessment framework is displayed in Table 3-3. It emphasizes quality in the design and implementation of the study, while evaluating the results to provide an overall assessment of the confidence that can be placed in the findings of the study.

The rating of high in a category provides an example of the elements that an ideal study would possess, while the rating of low to very low would indicate that elements of a suitable study are lacking or absent. An article will be required to achieve a minimum rating of *moderate* in each category in order for the reviewer to have a reasonably high level of confidence in the conduct and findings of the study so that it will be considered in the development of the options analysis.

TABLE 3-1 PROPOSED STANDARD INFORMATION COLLECTION FORM FOR SCIENTIFIC LITERATURE REVIEW – HUMAN STUDIES

Parameter	Value
Source	
Study ID	Assigned by Reviewer
Report ID	Assigned by Reviewer
Review Author ID	Assigned by Reviewer
Citation	
Contact Author Affiliation and Details	
Database	
Article Identifier/Digital Object Identifier (DOI)	
Keywords	
Language	
Available Online?	Yes/No
Peer Reviewed?	Yes/No
Abstract	
Eligibility	
Confirm Eligibility for Review	Yes/No
Reason for Exclusion	
Incinerator	
Location of Incinerator (e.g. Country, City, Area)	As described by article author.
Type of Incinerator (will standardize after if possible)	As described by article author.
Study Design	
Study objectives clearly defined	Yes/No
Study hypothesis clearly defined	Yes/No
Study type (cross sectional, longitudinal, retrospective, prospective, survey)	
Was the study type appropriate for the study objective?	Yes/No
Was the study sample representative of the population being studied?	Yes/No
Assignment (mainly for experimental studies)	
Was assignment of participants to study and control group proper?	Yes/No
Was there selection bias?	Yes/No
Was random and blind assignment maintained?	Yes/No
Were the study and control groups comparable?	Yes/No
Participants – Study Group	
Number of Participants	
Age of Participants	
Sex of Participants	
Location of Participants with respect to Incinerator	
Prior Exposure to Chemicals	Yes/No
Comparator Group	Yes/No
Participants – Control Group	
Number of Participants	
Age of Participants	
Sex of Participants	
Location of Participants with respect to Incinerator	
Prior Exposure to Chemicals	Yes/No
Methods/Analytical Procedure	
Study Duration	
Study Start/End Date	
Was Lifestyle Questionnaire Provided to Participants?	Yes/No
Medium Sampled	
Chemicals/Outcome Assessed	
Was the outcome measure appropriate to the objectives of the study?	Yes/No
Was the outcome measure precise and complete?	Yes/No
Did the observation process affect the outcome?	Yes/No
Sampling Location	
Samples Collected By	
Samples Collected In	
Sample Storage Method	

TABLE 3-1 PROPOSED STANDARD INFORMATION COLLECTION FORM FOR SCIENTIFIC LITERATURE REVIEW – HUMAN STUDIES

Samples Analyzed By	
Analysis Method	
Were Samples Pooled?	Yes/No
Were Sample Blanks Analyzed?	Yes/No
Was QA/QC Performed?	Yes/No
QA/QC Method	
Results	
Type of Statistical Analysis Performed	
Sample Size	
Were possible confounding variables taken into account?	Yes/No
Was a Test of Significance Performed?	Yes/No
P-Value between Sample and Control	
Was the null hypothesis properly rejected?	Yes/No
Were Type I and II errors considered in the interpretation of the meaning of the significance test?	Yes/No
Correlation of Chemical Levels to Incinerator	Positive/Negative/No Association
Was a proper measure of the size of difference presented?	Yes/No
Was a proper measure of the degree of overlap of the differences presented?	Yes/No
Were the concepts of association, cause and effect properly applied?	Yes/No
Were the limits of the data considered when extrapolating the results?	Yes/No
Was extrapolation to other populations beyond the study population valid?	Yes/No
Assumptions/Limitations of Study	
Biases Identified by Author	
Key Conclusions	
Miscellaneous	
Funding Source	
Further Correspondence with Author(s) Needed?	Yes/No
Contact Information	

TABLE 3-2 PROPOSED STANDARD INFORMATION COLLECTION FORM FOR SCIENTIFIC LITERATURE REVIEW - ENVIRONMENTAL STUDIES

Parameter	Value
Source	
Study ID	Assigned by Reviewer
Report ID	Assigned by Reviewer
Review Author ID	Assigned by Reviewer
Citation	
Contact Author Affiliation and Details	
Database	
Article Identifier/Digital Object Identifier (DOI)	
Keywords	
Language	
Available Online?	Yes/No
Peer Reviewed?	Yes/No
Abstract	
Eligibility	
Confirm Eligibility for Review	Yes/No
Reason for Exclusion	
Incinerator	
Location of Incinerator	As described by article author.
Type of Incinerator	As described by article author.
Study Design	
Study objectives clearly defined	Yes/No
Study hypothesis clearly defined	Yes/No
Study type (cross sectional, longitudinal, retrospective, prospective, survey)	
Was the study type appropriate for the study objective?	Yes/No
Was the study sample representative of the population being studied?	Yes/No
Study Group	
Number of Samples Taken	
Type of Sample Taken	
Location of Samples with respect to Incinerator	
Prior Exposure to Chemicals	
Control Group	
Number of Samples Taken	
Type of Sample Taken	
Location of Samples with respect to Incinerator	
Prior Exposure to Chemicals	Yes/No
Methods/Analytical Procedure	
Study Duration	
Study Start/End Date	
Chemicals/Outcome Assessed	
Was the outcome measure appropriate to the objectives of the study?	Yes/No
Was the outcome measure precise and complete?	Yes/No
Did the observation process affect the outcome?	Yes/No
Samples Collected By	
Samples Collected In	
Sample Storage Method	
Samples Analyzed By	
Analysis Method	
Were Samples Pooled?	Yes/No
Were Sample Blanks Analyzed?	Yes/No
Was QA/QC Performed?	Yes/No
QA/QC Method	
Results	
Type of Statistical Analysis Performed	
Sample Size	
P-Value between Sample and Control	

TABLE 3-2 PROPOSED STANDARD INFORMATION COLLECTION FORM FOR SCIENTIFIC LITERATURE REVIEW - ENVIRONMENTAL STUDIES

Were possible confounding variables taken into account?	Yes/No
Was the null hypothesis properly rejected?	Yes/No
Were Type I and II errors considered in the interpretation of the meaning of the significance test?	Yes/No
Was a proper measure of the size of difference presented?	Yes/No
Was a proper measure of the degree of overlap of the differences presented?	Yes/No
Were the concepts of association, cause and effect properly applied?	Yes/No
Were the limits of the data considered when extrapolating the results?	Yes/No
Was extrapolation to other populations beyond the study population valid?	Yes/No
Correlation of Chemical Levels to Incinerator	Positive/Negative/No Association
Assumptions/Limitations of Study	
Biases Identified by Author	
Key Conclusions	
Miscellaneous	
Funding Source	
Further Correspondence with Author(s) Needed?	Yes/No
Contact Information	

TABLE 3-3 PROPOSED QUALITY ASSESSMENT FRAMEWORK FOR EVALUATION OF IDENTIFIED ARTICLES

Category	Quality Level	Required Criteria
Study Design	High	- Retrospective and longitudinal study - Presence of study and multiple control groups - Adequate sample sizes to detect statistical differences - Baseline sampling results exists or conducted as part of study
	Moderate	- Cross-sectional study - Presence of study and single control group - Adequate sample sizes to detect statistical differences?
	Low	- Cross-sectional study - Presence of study group but no control group - Adequate sample sizes to detect statistical differences?
	Very Low	- Unspecific study type - Presence of study group but no control group - Sample sizes not adequate for proper interpretation of statistics
Study/Control Group Selection	High	- Participant/location selection method is fully detailed - Study group within typical deposition ranges of EFW; control group outside of EFW deposition range - Significant length of exposure to EFW - Groups controlled for *all* confounding factors: age, sex, socioeconomic status, occupational and other sources of exposure
	Moderate	- Brief to full detail on participant/location selection method - Study group within typical deposition ranges of EFW; control group outside of EFW deposition range - Significant length of exposure to EFW - Groups controlled for *most* confounding factors: age, sex, socioeconomic status, occupational and other sources of exposure
	Low	- Little detail on participant/location selection method - Study group within typical deposition ranges of EFW - Significant length of exposure to EFW - Groups controlled for *one or two* confounding factors: age, sex, socioeconomic status, occupational and other sources of exposure
	Very Low	- No detail on participant/location selection method - Study group not within typical deposition ranges of EFW - Insignificant length of exposure to EFW
Sample Collection	High	*Human* - Lifestyle and History Questionnaire completed by participants - Media (i.e. blood, urine, etc.) sampled by researchers directly, or by proxy (i.e. doctor, etc.) under researcher supervision - Analytical procedures outlined *Environmental* - Media (i.e. soil, water, etc.) sampled by researchers directly. - Collection methods, sample storage and sample preparation outlined - Analytical procedures outlined
	Moderate	*Human* - Lifestyle and History Questionnaire completed by participants - Media (i.e. blood, urine, etc.) sampled by researchers directly, or by licensed proxy - Analytical procedures outlined *Environmental* - Media (i.e. soil, water, etc.) sampled by researchers directly or by proxy. - Collection methods, sample storage and sample preparation outlined - Analytical procedures outlined
	Low	*Human* - Media (i.e. blood, urine, etc.) sampled by researchers directly, or by licensed proxy *Environmental* - Media (i.e. soil, water, etc.) sampled by researchers directly or by proxy.
	Very Low	*Human* - Data obtained from previously recorded patient records or effects self-reported by participants *Environmental* - Data obtained from previously conducted studies or from third-parties.
Critical Results Analysis	High	- Statistical analysis performed and procedure outlined - Issues of causality addressed - Conclusions are appropriate based on obtained results - Alternative hypotheses are considered
	Moderate	- Statistical analysis performed and procedure outlined - Issues of causality broached but not fully addressed - Conclusions are appropriate based on obtained results
	Low	- Basic quantitative analysis performed; no statistical analysis - Conclusions are appropriate based on obtained results
	Very Low	- Qualitative analysis only

4.0 EXTERNAL CONTACT / GREY LITERATURE REVIEW

4.1 Objectives

The objective of this section is to describe the process for the identification of external contacts to obtain information on environmental surveillance programs. Specifically, many governmental or legislated programs are not published in the scientific literature, relying instead on internal or external governmental websites and documents with limited dissemination. In order to obtain a more realistic indication of the best practices of environmental surveillance programs associated with the energy-from-waste industry, it is essential to complete a review of such limited distribution but potentially highly relevant, materials.

4.2 Overview of External Information Gathering Process

Figure 4-1 outlines the Study Protocol that will be used for contacting and obtaining relevant information from external sources. Once an individual who may possess relevant information is identified, a standard email describing the project will be sent to this person (Appendix B). The email will request a phone interview with the individual based on questions provided in a questionnaire to be sent prior to the phone call. If no reply is received within 7 days of the initial email, a standard follow-up email will be sent reminding the individual of the project and the desire to obtain information. If no reply to the follow-up email is received, attempts will be made to contact the individual by telephone. Should this fail, the reviewer will move on to other individuals identified for contact.

Once contact has been made, and the individual has agreed to move forward in the process, a standard email will be sent to the individual containing the questionnaire, and an invitation to send a selection of times at which the individual is available for a phone-based interview. The questionnaires are designed to obtain a maximum amount of information using a minimum number of questions. As with any survey, the response rate can generally be correlated to the level of effort required to complete the survey/questionnaire. At the selected time, the reviewer will then call the individual and conduct the interview. The reviewer will take notes of the conversation throughout the interview and immediately following the interview, prepare a summary report outlining the information obtained. The reviewer should take the opportunity to question the individual for other contacts who might possess useful information for the purposes of the review and then add these new individuals to the contact list. At this point it would not be the intent of the Study Team to keep the identities protected; however if an individual asks this to be done only the core Study Team members will be able to identify them through a numbering system.

Every attempt will be made through the interview process to understand the costs (on an annual basis) associated with their individual programs. However, it is possible that the Study Team will not be able to obtain this information based on confidentiality issues.

The response to questions will then be emailed to the interviewee, to ensure consistency in the collection of their responses. Examples of the standard emails, as well as the questionnaires, can be found in Appendix B.

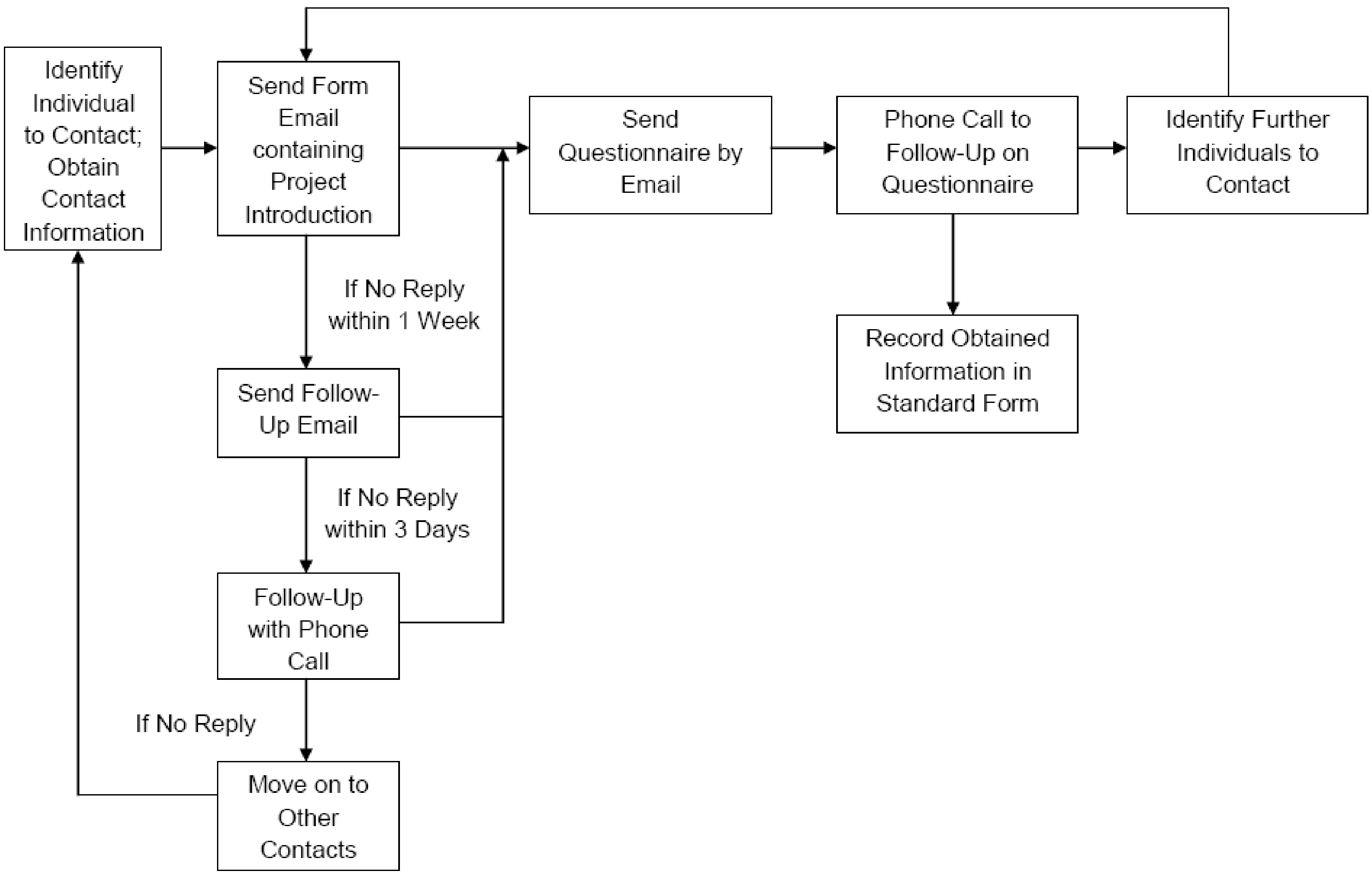

FIGURE 4-1 OVERVIEW OF EXTERNAL CONTACT PROCEDURE

4.3 Contact Selection

The selection of individuals to contact during this process will proceed in a two tiered format. Tier 1 will consist of all previously established contacts, including among them, the list of EFW facilities visited by the municipality upon their incinerator tour of Europe, as well as the list of academic and governmental members associated with the European Union Human Biomonitoring Implementation Group. A list of known Tier 1 candidates for potential interview is included in Appendix C. In addition, contacts at the Ontario Ministry of the Environment (MOE), Health Canada Canadian Health Measures Survey, and environmental regulators in other Canadian jurisdictions will be contacted.

Tier 2 contacts are those that will be identified throughout the review process and will consist of supplemental contacts identified during the contact of Tier 1 individuals, as well as authors of articles found and deemed relevant in the scientific literature search.

4.4 Grey Literature Review

While contacting a large number of individuals in research, industry and government will likely bring forth considerable information, much of it will likely come in the form of grey literature – that is, literature not produced by bodies whose sole objective is publishing or that is not indexed in a scientific database. This might include technical reports, government publications, regulations and legislation, conference proceedings, presentations, or unfinished “working reports”. Any leads provided by external contacts towards these types of documents will be followed up and attempts to retrieve the documents made.

Further to this, an internet-based grey literature search will be conducted to locate and identify relevant works. Combinations of relevant keywords from the systematic review of the scientific literature will be searched on two common search engines, Google™ and Yahoo!®. The reproducibility of this grey literature search is not guaranteed as internet-based search engines are dynamic and search results from specific terms tend to change over time based on page popularity and search engine algorithms. The criteria for relevance of documents are identical to those outlined for the scientific literature review – English language, published after the year 1990, clearly defined study population exposed to incineration by-products, and a clearly defined and relevant outcome of interest. Results of the grey literature search that are deemed relevant will be assessed for quality based on the framework presented for the scientific literature review (Table 3-3). However, unlike the results of the scientific literature search which are relatively uniform in style and structure, the results of the grey literature search will likely vary widely in the information they present and the methods used to present it. Consequently, the quality assessment framework will be adapted independently by the reviewers for each document based on the presentation of the information. The quality assessment of these documents will be expanded on in the final deliverable such that any reviewer bias is made transparent.

This internet-based grey literature search will also be used to further identify individuals or organizations involved in environmental surveillance programs around incinerator facilities. These individuals will then be added to the Tier 2 list of contacts such that additional information can be gained from their expertise. The result of this process is a "revolving door" type cycle where a contact provides information which is used to identify another contact that can provide information (Figure 4-2). As long as the "door continues to revolve", so will the information gathering process.

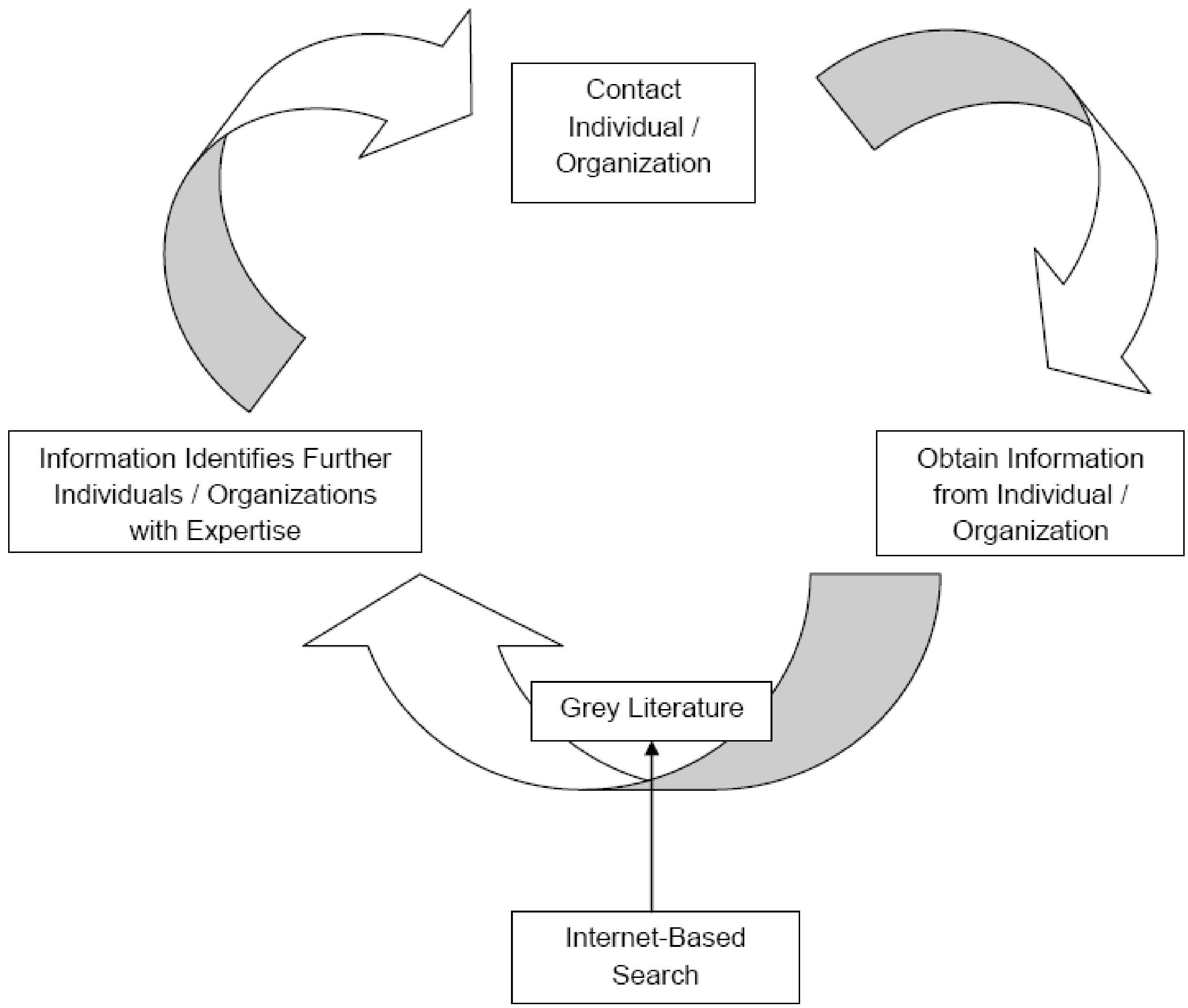

FIGURE 4-2 INFORMATION GATHERING PROCESS RESULTS IN A "REVOLVING DOOR" TYPE CYCLE

5.0 SUMMARY OF CURRENT PRACTICES OF ENVIRONMENTAL SURVEILLENCE RELATED TO EFW FACILITIES

Once all of the aforementioned tasks – systematic literature review, background and grey literature search and interviews - have been completed, the Study Team will compile summaries of the information on current practices of environmental surveillance as they relate to EFW facilities from around the world.

At this point it is premature to determine exactly how these summaries will be presented. However, it is likely that summaries will be provided by:

- Individual Facility
- Regulatory Jurisdiction
- Country

These summaries will be factual accounts of the current practices of environmental surveillance and will not comment on their adequacy or individual applicability for the proposed EFW facility in the Region of Durham. However, an attempt will be made to understand if the responsible regulatory authorities believe the surveillance program in place in their jurisdictions are adequate to ensure the protection of health and the environment.

Every attempt will be made to understand the cost of the individual programs on an annual basis; however, this information is not considered critical to understanding the nature of the programs that have been put in place to ensure the protection of public health and the environment.

These summaries will be critical in the development of options for an environmental surveillance program for the Durham/York EFW facility.

6.0 OPTIONS ANALYSIS

Based on the results of the study and the summary of international current practices of environmental surveillance at EFW facilities, a series of options will be developed for consideration. At the time of preparation of the Study Protocol it was believed that it would be premature to develop the detailed methodology for conducting the options analysis. However, the following will be the stepwise approach that will be followed:

Step 1: The Study Team will develop a list of environmental surveillance options that will be based on practices being conducted internationally for EFW facilities.

Step 2: The list of environmental surveillance options will be issued for independent third-party peer review to ensure its completeness.

Step 3: The Study Team will develop a consultant's preferred option.

Step 4: The preferred option will be issued for independent third-party peer review and comment.

Step 5: The Report, which will include the Options Analysis and the Consultant's preferred option, will be presented to Committees and Council for consideration and direction for next steps.

It is expected that the minimum option that could be developed for consideration will be that which would be required by the Ontario Ministry of the Environment (MOE) for the operation of such a facility. The remaining options will be presented in a tiered or stepwise approach from this base option. An initial cost estimate for each of the presented options will be provided based on the experience of the Study Team in conducting projects of a similar nature.

Detailed costing of each option will not be feasible at this stage of the Study.

The overall objective of this review process is to provide the Regions of Durham and York, a range of environmental surveillance options that could be considered for implementation if the proposed EFW facility is to be built at the Clarington 01 site.

> *"The consultant's recommended option for an environmental surveillance program for the proposed Durham/York Residual EFW facility will be based on the fundamental tenant that the program must ensure the protection of public and environmental health."*

7.0 STUDY TEAM, SCHEDULE AND DELIVERABLES

7.1 Study Team

A multidisciplinary team of professionals has been assembled to tackle this unique study question. A brief cameo of each member and their role is provided below.

Dr. Christopher Ollson – Study Team Director

Dr. Ollson is Jacques Whitford's National Director of Environmental Health Sciences and is located within the Burlington office. He is recognized by the Ontario Ministry of the Environment as a Qualified Person Risk Assessment under Ontario Regulation 153/04 and as a Qualified Toxicologist through the Air Standards Development Branch. Throughout his career, Dr. Ollson has led numerous multidisciplinary environmental health assessments and facilitated community consultation and risk communication for both industry and government agencies. Stakeholder engagement ensured that communities were part of the decision-making process with regards to issues surrounding airborne, soil and water contaminant emissions, or public health concerns associated with industrial facilities or contaminated site remediation.

Dr. Ollson has been involved in some of Canada's largest and most complex risk assessment and environmental assessment projects. These include the Human Health and Ecological Risk Assessment in support of the Environmental Assessment that was conducted for the proposed new Shell Canada refinery in Sarnia; Environmental Site Assessment of Herbicide Application at CFB Gagetown, NB; the proposed Bennett Thermal Oxidation Facility for disposal of hydrocarbon impacted soil in Belledune, NB; the Catalyst Pulp and Paper baseline airshed health assessment in Crofton, BC; Enbridge Gateway Project in Alberta and BC; the Sydney Tar Ponds proposed incinerator remediation facility in Cape Breton, NS; Petro-Canada's Sturgeon Upgrader; Syneco's Northern Lights Project and the INCO refinery, Port Colborne Community Based Risk Assessment in Port Colborne, ON.

Most recently Dr. Ollson was the lead author in the development of a Framework for Public Health Officials to Integrate Health Impact Assessment Considerations in Municipal Project Undertakings for the City of Toronto. He is also the Senior Project Lead for the Site Specific Risk Assessment to be conducted for the Durham/York Residual Waste environmental assessment.

Dr. Christofer Balram –Subject Matter Expert and Internal Study Review

Dr. Christofer Balram held several senior positions in the New Brunswick Public Service during the period 1986 - 2008. He was the Provincial Epidemiologist and the Director of the New Brunswick Provincial Epidemiology Service. He also held other senior positions concurrently - Director of Health Promotion and Disease Prevention, Director of the New Brunswick Cancer Registry and the Director of the New Brunswick Serum Depot. Before joining the Public Service he held full-time medical faculty appointments at Memorial University of Newfoundland and Dalhousie University in Nova Scotia. He is a certified member of the American College of Epidemiology. He is a graduate of Memorial University, holds a BA in Sociology and Anthropology, BSc in Biochemistry, MSc in Medicine and a PhD in Medicine. He also holds an MD in Alternative Medicine from Calcutta, India.

Dr Balram has worked on numerous Health Studies in the capacity of Lead Investigator and/or Senior Professional in the Department of Health responsible for the conduct of these studies. They include The Greater Belledune Area Health Study that evaluated the impact of the Belledune Lead Smelter on the health of residents living in the area; the McAdam Health Study which investigated high cancer rates in the community, the Town of Newcastle Health Study which evaluated the impact of chemicals in the environment on the health of residents and Blood Lead levels in Children living in Saint John, New Brunswick. He was also a member of the CFB Gagetown Advisory Panel that advised the Federal Government on the impact of Agent Orange on the health of workers and residents. Dr. Balram has written many reports and scientific papers, in addition to making numerous scientific presentations to health professionals and the public.

Kaitryn Campbell, BAH, BEd, MLIS – Health Sciences Information Specialist / Librarian

Ms. Campbell has been a Health Sciences Information Specialist for seven years. Since graduating with her Masters of Library and Information Science from the University of Western Ontario in 2001 she has held positions at the Children's Hospital of Eastern Ontario (CHEO), the Ottawa Hospital, the Canadian Agency for Drugs and Technologies in Health (CADTH) and is currently employed by the Programs for Assessment of Technology in Health (PATH) research group at McMaster University. Her expertise lies in the development and conduct of literature search strategies and information retrieval for systematic reviews related to topics in the health sciences.

Mathieu Morin, M.Env.Sc. – Study Team Member

Mathieu Morin is with the Environmental Health Sciences group at Jacques Whitford Limited. He holds a Bachelor's of Science in Engineering degree in Engineering Chemistry from Queen's University and a Masters of Environmental Science Degree from the University of Toronto. His experiences and background have provided him the opportunity to gain significant knowledge in the fields of environmental and health sciences. Specific projects completed at the University of Toronto include a theoretical human health and ecological risk assessment on the application of DDT for the treatment of malaria, as well as thorough scientific literature reviews on PAH contamination in soil, and radon contamination in groundwater. Since joining Jacques Whitford, Mr. Morin has had the opportunity to contribute to a number of projects prior to the current review, including several human health and ecological risk assessments for contaminated sites, as well as the development of a corporate policy-based influenza pandemic plan.

Sarah Henderson, B.A.(H.) – Study Team Member

Sarah Henderson is a scientist with the Environmental Health Sciences group at Jacques Whitford Limited. Her work at Jacques Whitford is concentrated on this systematic review of literature on the international environmental monitoring best practices for incinerators. Ms. Henderson holds a Bachelor of Arts (Honours) degree in Geography and Environmental Studies from McMaster University. While at McMaster University, she gained useful knowledge in environmental impact assessments as well as environment and health. Ms. Henderson also had the opportunity to assist with full-scale systematic literature reviews while employed as at the Programs for Assessment of Technology in Health research group (PATH). As a result of her time at PATH, she has gained extensive knowledge in literature retrieval, literature screening and bibliographic software applications.

7.2 Schedule

Table 7-1 outlines the proposed schedule for the execution of the review. The scientific literature search has begun from a preparatory standpoint and will continue through to the end of October, 2008. Contact with qualified individuals in the field will begin in October and carry through to the end of November. This process is expected to be lengthy as professional schedules must be accommodated in an effort to minimize any inconveniences on the part of the individuals.

In late November/early December, the review team will begin collating the information with the intent of providing an analysis of the options available for surveillance. A draft of the report with the consultant's preferred option for environmental surveillance will be ready for presentation no later than January 15, 2009. The final report will then be finalized by the end of February. The timeline allows adequate time for the review team to complete a succinct and comprehensive review, and concurrently, fits into the general timeline of the Durham/York Residual Waste Study.

TABLE 7-1 PROPOSED SCHEDULE FOR EXECUTION OF REVIEW

Task	Schedule of Work	Deliverable Date
Protocol and Scoping Report	Completed	November 4, 2008
Literature Review	Ongoing – October	In Draft Report
External Contact Information Gathering (Best Practices Discussions)	October – November	
Options Analysis	November – December	
Draft Report	December – January	January 15, 2009
Final Report	January – February	February 28, 2009

7.3 Deliverables

The draft report, to be presented January 15, 2009, will provide the full results of the study to be conducted. The report will be structured in a manner similar to the Study Protocol report at hand. An overview of the project and the objectives of the review will be provided followed by background information on environmental surveillance. The systematic scientific literature review will then be presented. The Study Protocol will be repeated and any changes from the current Study Protocol will be outlined with a rationale. A summary analysis of the final collection of relevant articles will be presented as well as an analysis of the quality assessment results, outlining the level of confidence that can be placed in the final conclusions of the scientific literature review. The data collected within the information collection forms for each article reviewed will be presented in an Appendix.

The results of the external contact information gathering process will be presented in the form of a summary analysis. A record of contact with each individual will be presented along with a brief report of each interview conducted. The results of the grey literature search will be summarized along with further details on the quality assessment process adapted to each resulting document.

The results of both review processes presented, the following section will strive to unite the results into a summary regarding best practices for environmental surveillance programs in the vicinity of incineration facilities. A country-by-country approach may be taken to best understand the regulatory framework, which is sure to differ widely among nations. This summary will feed into the options analysis that will present a series of environmental surveillance options for the Regions to consider. At the request of the client, a consultant's preferred option will be specified.

8.0 REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 1996. Guidance for ATSDR Health Studies.

Angerer, J. et al. 2007. Human Biomonitoring: State of the Art. *International Journal of Hygiene and Environmental Health,* **210,** 201-228.

CEC (Commission of the European Communities). 2004. Volume II - Technical Annexes to the Communication of the Commission on the European Environment and Health Action Plan 2004-2010. COM(2004) 416 Final.

Cochrane Collaboration. 2008. Cochrane Handbook for Systematic Reviews of Interventions Version 5.0.0. Higgins JPT, Green S (editors). URL: http://www.cochrane-handbook.org/

ESBIO (Expert Team to Support Biomonitoring in Europe). 2007. Development of a Coherent Approach to Human Biomonitoring in Europe – Publishable Final Activity Report.
European Commission. 2007. Work Programme 2007 – Cooperation – Theme 6 – Environment (including Climate Change).

European Human Biomonitoring. 2005. List of Governmental Representatives. URL: http://www.eu-humanbiomonitoring.org/doc/list_political_0505.doc

European Human Biomonitoring. 2008. Members of the Group. URL: http://www.eu-humanbiomonitoring.org/sub/implgroup/members.htm

Health Canada. 2007a. Human Biomonitoring of Environmental Chemicals. URL: http://www.hc-sc.gc.ca/ewh-semt/contaminants/biomonitoring-biosurveillance-eng.php

Health Canada. 2007b. Biomonitoring of Environmental Chemicals in the Canadian Health Measures Survey. URL: http://www.hc-sc.gc.ca/ewh-semt/contaminants/health-measures-sante-eng.php

Health Canada. 2007c. Maternal-Infant Research on Environmental Chemicals (The MIREC Study). URL: http://www.hc-sc.gc.ca/ewh-semt/contaminants/mirec/index-eng.php

Jacques Whitford. 2008. Draft Interim Report on Ambient Air Monitoring at the Courtice Road Site. October 1, 2008.

Kapral, M.K., Wang, H., Mamdani, M., Tu, J.V., 2002. Effect of Socioeconomic Status on Treatment and Mortality After Stroke. *Stroke.* 33:268.

Last, J.M, ed. 2000. A Dictionary of Epidemiology, 4th Edition. Oxford University Press: USA, p.117.

National Research Council (NRC). 2000. Waste Incineration and Public Health. National Academy Press: Washington, DC, pp112-181.

NHANES. 2007. Data Accomplishments. URL: http://www.cdc.gov/nchs/about/major/nhanes/DataAccomp.htm

Reis, M.F. et al. 2008. Ethics Issues Experienced in HBM within Portuguese Health Surveillance and Research Projects. *Environmental Health*, **7 (Suppl 1): S5.**

Rothman, K.J. and S. Greenland. 1998. Modern Epidemiology, 2nd Edition. Lippincott Williams & Wilkins, p435.

Smith, L. 2007. Energy from Waste Facility in the Region of Durham. URL: http://www.region.durham.on.ca/departments/health/pub/energyFromWasteReport.pdf

United Nations Food and Agriculture Organization (UN FAO). 1990. Watershed Management Field Manual.

World Health Organization. World Health Survey. Web site accessed October 1, 2008. http://www.who.int/healthinfo/survey/en/index.html

APPENDIX A

Scientific Literature Search Strategy

The following are the search strategies that were used in the Systematic Literature Review. The descriptors (also called subject headings or controlled terminology) and syntax were tailored to meet the demands of the particular database in use, as each database is unique in the descriptors and syntax required. For example, when searching PubMed or MEDLINE, Medical Subject Heading (MeSH) descriptors were used, as this is the terminology required to search this database. An example of this would be the use of the general "Environmental Pollutants" MeSH descriptor in place of specifying all potential environmental pollutants.

The final search set will provide the final set of results which will be subjected to the inclusion/exclusion criteria. It should be noted that all exclusion criteria (i.e. with the exception of limiting the publication date from 1990-present) will be applied after-the-fact by the reviewers, and will not be integrated into the search.

Some specifications have been omitted based on the strategy of the search. For example, there is no need to search for different types of incinerators (i.e. municipal waste incinerator, hazardous waste incinerator, etc.). Simply searching for keyword *incinerat** should bring forward all such articles as incinerator is always used to qualify the facility regardless of the type of waste burnt.

OVID DATABASE

Medline In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) <1950 to Present>

Limits: 1990-present

1. Pollutant Exposure

exp Environmental Exposure/
exp Environmental Pollutants/ OR Environmental Pollution.sh. OR exp Air Pollution/ OR exp Water Pollution/
Metals, Heavy.sh.

AND

2. Incineration

Incineration.sh.
Refuse Disposal.sh. (1990-1993)

AND

3. Type of Measurement (or Study)

ae.fs.
exp Cohort Studies/
Epidemiologic Methods.sh.
ep.fs.
exp Body Burden/
Environmental Monitoring.sh.
Data Collection.sh. OR Health Surveys.sh. OR exp Population Surveillance/ OR Questionnaires.sh.

Search run 1Oct2008

1 exp Environmental Exposure/ (144426)
2 exp Environmental Pollutants/ or Environmental Pollution.sh. or exp Air Pollution/ or exp Water Pollution/ (304901)
3 Metals, Heavy.sh. (8165)
4 (exposur$ or exposed).ti,ab. (949765)
5 (((air or environmental or soil or water) adj (pollutant$ or pollution)) or air quality or gas$ emission?).ti,ab. (38477)
6 (benzofuran? or dioxin? or polychlorodibenzo-4-dioxin? or polychlorinated dibenzodioxin? or polychlorinated dibenzofuran? or PCDD? or dibenzofuran? or tetrachlorodibenzo-p-dioxin? or tetrachlorodibenzodioxin? or TCDD? or furan? or hexachlorobenzene? or polychlorinated biphenyl? or PAH? or polycyclic aromatic hydrocarbon? or volatile organic compound? or heavy metal? or lead or chromium or cadmium or mercury).mp. (673533)
7 (Environmental Exposure or Occupational Exposure or Population Exposure).sh. (135209)
8 (Air Pollution or Soil Pollution).sh. or exp Water Pollution/ or Pollutant.sh. or Air Pollutant.sh. or Gas Waste.sh. or Soil Pollutant.sh. (118705)
9 or/1-6 (1773312)
10 or/4-8 (1667502)
11 Incineration.sh. (5799)
12 Refuse Disposal.sh. (7770)
13 limit 12 to yr="1990 - 1993" (770)
14 (energy from waste or EFW or incinerat$ or thermal destruction or thermal treatment$).ti,ab. (9619)
15 Incineration.sh. (5799)
16 or/11,13-14 (12128)
17 or/14-15 (11442)
18 ae.fs. (1530999)

19	exp Cohort Studies/	(749194)
20	Epidemiologic Methods.sh.	(23273)
21	ep.fs.	(1203093)
22	exp Body Burden/	(16125)
23	Environmental Monitoring.sh.	(52533)
24	(Data Collection or Health Surveys).sh. or exp Population Surveillance/ or Questionnaires.sh.	(355587)
25	((adverse adj2 effect$) or adverse$ affect$).ti,ab.	(165040)
26	cohort$.ti,ab.	(252240)
27	(prospective adj (study or studies or trial or trials)).ti,ab.	(159570)
28	(longitudinal adj (study or studies or trial or trials)).ti,ab.	(48469)
29	((follow up or followup) adj (study or studies or trial or trials)).ti,ab.	(49448)
30	(epidemiologic$ adj (method$ or study or studies)).ti,ab.	(77083)
31	(biosurveillance or bio-surveillance or surveillance).ti,ab.	(109277)
32	body burden.ti,ab.	(2897)
33	(health adj (effect$ or hazard$ or outcome$ or study or studies)).ti,ab.	(51346)
34	(biomonitor$ or bio-monitor$ or measure$ or monitor$).mp.	(3360912)
35	environmental impact.ti,ab.	(3214)
36	(questionnaire$ or survey$).ti,ab.	(678164)
37	exp Cohort Analysis/ or Follow Up.sh. or Longitudinal Study.sh. or Prospective Study.sh.	(1069451)
38	Epidemiological Data.sh.	(16621)
39	ep.fs.	(1203093)
40	Body Burden.sh.	(6490)
41	Health Hazard.sh.	(20160)
42	(Air Monitoring or Biological Monitoring or Environmental Monitoring or Pollution Monitoring).sh.	(67231)
43	(Environmental Impact or Environmental Impact Assessment).sh.	(11284)
44	Health Survey.sh. or exp Questionnaire/ or Population Risk.sh. or Population Research.sh.	(397033)
45	(Controlled Study or Major Clinical Study).sh.	(3223217)
46	or/19-36	(5659857)
47	or/25-45	(7927844)
48	46 and 16 and 9	(2808)
49	limit 48 to yr="1990 - 2009"	(2674)
50	10 and 17 and 47	(2592)
51	limit 50 to yr="1990 - 2009"	(2473)
52	from 49 keep 1-1403	(1403)
53	from 51 keep 1087-2473	(1387)

PubMed DATABASE

Limits: 1990-present

1. Pollutant Exposure
Environmental Exposure[mh]
Environmental Pollutants[mh] OR Environmental Pollution[mh:noexp] OR Air Pollution[mh] OR Water Pollution[mh]
Metals, Heavy[mh:noexp]
exposur*[tiab] OR exposed[tiab]
air pollutant*[tiab] OR environmental pollutant*[tiab] OR soil pollutant*[tiab] OR water pollutant*[tiab] OR air pollution[tiab] OR environmental pollution[tiab] OR soil pollution[tiab] OR water pollution[tiab] OR air quality[tiab] OR gas* emission*[tiab]
benzofuran*[all fields] OR dioxin*[all fields] OR polychlorodibenzo-4-dioxin*[all fields] OR polychlorinated dibenzodioxin*[all fields] OR polychlorinated dibenzofuran*[all fields] OR PCDD*[all fields] OR dibenzofuran*[all fields] OR tetrachlorodibenzo-p-dioxin*[all fields] OR tetrachlorodibenzodioxin*[all fields] OR TCDD*[all fields] OR furan*[all fields] OR hexachlorobenzene[all fields] OR polychlorinated biphenyl*[all fields] OR PAH*[all fields] OR polycyclic aromatic hydrocarbon*[all fields] OR volatile organic compound*[all fields] OR heavy metal*[all fields] OR lead[all fields] OR chromium[all fields] OR cadmium[all fields] OR mercury[all fields]

AND

2. Incineration
Incineration[mh]
Refuse Disposal[mh:noexp] (1990-1993)
energy from waste[tiab] OR EFW[tiab] OR incinerat*[tiab] OR thermal destruction[tiab] OR thermal treatment*[tiab]

AND

3. Type of Measurement (or Study)
adverse effects[MeSH subheading]
Cohort Studies[mh]
Epidemiologic Methods[mh:noexp]
epidemiology[MeSH subheading]
Body Burden[mh]
Environmental Monitoring[mh:noexp]
Data Collection[mh:noexp] OR Health Surveys[mh:noexp] OR Population Surveillance[mh] OR Questionnaires[mh:noexp]
adverse effect*[tiab] OR adverse* affect*[tiab]
cohort*[tiab] OR prospective study[tiab] OR prospective studies[tiab] OR prospective trial*[tiab] OR longitudinal study[tiab] OR longitudinal studies[tiab] OR longitudinal trial*[tiab]
follow up study[tiab] OR follow up studies[tiab] OR follow up trial*[tiab] OR followup study[tiab] OR followup studies[tiab] OR followup trial*[tiab]
epidemiologic* method*[tiab] OR epidemiologic* study[tiab] OR epidemiologic* studies[tiab]
biosurveillance[tiab] OR bio-surveillance[tiab] OR surveillance[tiab] OR body burden[tiab]
health effect*[tiab] OR health hazard*[tiab] OR health outcome*[tiab] OR health study[tiab] OR health studies[tiab]
biomonitor*[all fields] OR bio-monitor*[all fields] OR measure*[all fields] OR monitor*[all fields] OR environmental impact[tiab] OR questionnaire*[tiab] OR survey*[tiab]
AND
in process[sb] OR publisher[sb] OR pubmednotmedline[sb]

Search run 1Oct2008

#28	Search #26 AND #27	17:25:09	50
#27	Search in process[sb] OR publisher[sb] OR pubmednotmedline[sb]	17:24:41	1021967
#26	Search **(#1 OR #2 OR #3 OR #4 OR #5 OR #6) AND (#8 OR #9 OR #10) AND (#11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24)** Limits: **Entrez Date from 1990 to 2009**	17:22:56	1521
#25	Search **(#1 OR #2 OR #3 OR #4 OR #5 OR #6) AND (#8 OR #9 OR #10) AND (#11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17 OR #18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24)**	17:22:17	1588
#24	Search **biomonitor*[all fields] OR bio-monitor*[all fields] OR measure*[all fields] OR monitor*[all fields] OR environmental impact[tiab] OR questionnaire*[tiab] OR survey*[tiab]**	17:17:54	2193460
#23	Search **health effect*[tiab] OR health hazard*[tiab] OR health outcome*[tiab] OR health study[tiab] OR health studies[tiab]**	17:17:19	27312
#22	Search **biosurveillance[tiab] OR bio-surveillance[tiab] OR surveillance[tiab] OR body burden[tiab]**	17:17:02	62330
#21	Search **epidemiologic* method*[tiab] OR epidemiologic* study[tiab] OR epidemiologic* studies[tiab]**	17:16:32	50857
#20	Search **follow up study[tiab] OR follow up studies[tiab] OR follow up trial*[tiab] OR followup study[tiab] OR followup studies[tiab] OR followup trial*[tiab]**	17:16:17	29873
#19	Search **cohort*[tiab] OR prospective study[tiab] OR prospective studies[tiab] OR prospective trial*[tiab] OR longitudinal study[tiab] OR longitudinal studies[tiab] OR longitudinal trial*[tiab]**	17:15:46	231079
#18	Search **adverse effect*[tiab] OR adverse* affect*[tiab]**	17:15:17	64933
#17	Search **Data Collection[mh:noexp] OR Health Surveys[mh:noexp] OR Population Surveillance[mh] OR Questionnaires[mh:noexp]**	17:15:02	282968
#16	Search **Environmental Monitoring[mh:noexp]**	17:14:51	36742
#15	Search **Body Burden[mh]**	17:14:43	13490
#14	Search **epidemiology[MeSH subheading]**	17:14:34	1063604
#13	Search **Epidemiologic Methods[mh:noexp]**	17:14:25	22435
#12	Search **Cohort Studies[mh]**	17:14:14	669526
#11	Search **adverse effects[MeSH subheading]**	17:14:03	1293934
#10	Search **energy from waste[tiab] OR EFW[tiab] OR incinerat*[tiab] OR thermal destruction[tiab] OR thermal treatment*[tiab]**	17:13:22	4425
#9	Search **Refuse Disposal[mh:noexp]** Limits: **Publication Date from 1990 to 1993**	17:13:07	751
#8	Search **Incineration[mh]**	17:12:32	2198
#6	Search **benzofuran*[all fields] OR dioxin*[all fields] OR polychlorodibenzo-4-dioxin*[all fields] OR polychlorinated dibenzodioxin*[all fields] OR polychlorinated dibenzofuran*[all fields] OR PCDD*[all fields] OR dibenzofuran*[all fields] OR tetrachlorodibenzo-p-dioxin*[all fields] OR tetrachlorodibenzodioxin*[all fields] OR TCDD*[all fields] OR furan*[all fields] OR hexachlorobenzene[all fields] OR polychlorinated biphenyl*[all fields] OR PAH*[all fields] OR polycyclic aromatic hydrocarbon*[all fields] OR volatile organic compound*[all fields] OR heavy metal*[all fields] OR lead[all fields] OR chromium[all fields] OR cadmium[all fields] OR mercury[all fields]**	17:11:35	378666
#5	Search **air pollutant*[tiab] OR environmental pollutant*[tiab] OR soil pollutant*[tiab] OR water pollutant*[tiab] OR air pollution[tiab] OR environmental pollution[tiab] OR soil pollution[tiab] OR water pollution[tiab] OR air quality[tiab] OR gas* emission*[tiab]**	17:10:19	5410
#4	Search **exposur*[tiab] OR exposed[tiab]**	17:10:07	540251
#3	Search **Metals, Heavy[mh:noexp]**	17:09:55	8012
#2	Search **Environmental Pollutants[mh] OR Environmental Pollution[mh:noexp] OR Air Pollution[mh] OR Water Pollution[mh]**	17:09:45	140521
#1	Search **Environmental Exposure[mh]**	17:09:33	110630

Toxline DATABASE

Search run 1Oct2008
(exposure OR exposures OR exposed OR pollutant) AND ("energy from waste" OR EFW OR incinerat* OR "thermal destruction" OR "thermal treatment") AND ("adverse effect" OR "adverse affect" OR cohort OR prospective OR longitudinal OR "follow up" OR followup OR epidemiologic* OR biosurveillance OR bio-surveillance OR surveillance OR "body burden" OR "health effect" OR "health hazard" OR "health outcome" OR "health study" OR "health studies" OR biomonitor* OR bio-monitor* OR measure* OR monitor* OR "environmental impact" OR questionnaire OR survey)

=1623 results,1076 from 1990-present

Cambridge Scientific's Environmental Science and Pollution Management (via Scholar's Portal) **DATABASE**

1990-present

exposur* OR exposed
"air pollutant*" OR "environmental pollutant*" OR "soil pollutant*" OR "water pollutant*" OR "air pollution" OR "environmental pollution" OR "soil pollution" OR "water pollution" OR "air quality"
benzofuran* OR dioxin* OR polychlorodibenzo-4-dioxin* OR "polychlorinated dibenzodioxin*" OR "polychlorinated dibenzofuran*" OR PCDD* OR dibenzofuran* OR tetrachlorodibenzo-p-dioxin* OR tetrachlorodibenzodioxin* OR TCDD* OR furan* OR hexachlorobenzene OR "polychlorinated biphenyl*" OR PAH* OR "polycyclic aromatic hydrocarbon*" OR "volatile organic compound*" OR "heavy metal*" OR lead OR chromium OR cadmium OR mercury

AND

"energy from waste" OR EFW OR incinerat* OR "thermal destruction" OR "thermal treatment*"

AND

cohort* OR "prospective study" OR "prospective studies" OR "prospective trial*" OR "longitudinal study" OR "longitudinal studies" OR "longitudinal trial*" OR "follow up study" OR "follow up studies" OR "follow up trial*" OR "followup study" OR "followup studies" OR "followup trial*"
"adverse effect*" OR "adverse* affect*" OR "epidemiologic* method*" OR "epidemiologic* study" OR "epidemiologic* studies" OR biosurveillance OR "bio-surveillance" OR surveillance OR "body burden"
"health effect*" OR "health hazard*" OR "health outcome*" OR "health study" OR "health studies" OR biomonitor* OR "bio-monitor*" OR measure* OR monitor* OR "environmental impact" OR questionnaire* OR survey*

Search run 3Oct2008, =1039 results

The Cochrane Library (Wiley) 2008, Issue 3 DATABASE

Limits: 1990-present

1. Pollutant Exposure
Environmental Exposure[mh]
Environmental Pollutants[mh] OR Environmental Pollution[mh:noexp] OR Air Pollution[mh] OR Water Pollution[mh]
Metals, Heavy[mh:noexp]

exposur* OR exposed

air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*

benzofuran* OR dioxin* OR polychlorodibenzo-4-dioxin* OR polychlorinated dibenzodioxin* OR polychlorinated dibenzofuran* OR PCDD* OR dibenzofuran* OR tetrachlorodibenzo-p-dioxin*

tetrachlorodibenzodioxin* OR TCDD* OR furan* OR hexachlorobenzene OR polychlorinated biphenyl* OR PAH* OR polycyclic aromatic hydrocarbon* OR volatile organic compound* OR heavy metal* OR lead OR chromium OR cadmium OR mercury

AND

2. Incineration
Incineration[mh]
Refuse Disposal[mh:noexp] (1990-1993)

"energy from waste" OR EFW OR incinerat* OR "thermal destruction" OR "thermal treatment*"

Search run 1Oct2008 = 4 results in CENTRAL

<u>Biosis Previews (Thompson), 1995-2008 DATABASE</u>

Limits: 1995-present

1. Pollutant Exposure

MC=(exposur* OR exposed) OR DE=(exposur* OR exposed) OR TS=(exposur* OR exposed) OR TI=(exposur* OR exposed)

MC=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*) OR DE=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*)

TS=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*) OR TI=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*)

MC=(benzofuran* OR dioxin* OR polychlorodibenzo-4-dioxin* OR polychlorinated dibenzodioxin* OR polychlorinated dibenzofuran* OR PCDD* OR dibenzofuran* OR tetrachlorodibenzo-p-dioxin*) OR DE=(benzofuran* OR dioxin* OR polychlorodibenzo-4-dioxin* OR polychlorinated dibenzodioxin* OR polychlorinated dibenzofuran* OR PCDD* OR dibenzofuran* OR tetrachlorodibenzo-p-dioxin*)

TS=(benzofuran* OR dioxin* OR polychlorodibenzo-4-dioxin* OR polychlorinated dibenzodioxin* OR polychlorinated dibenzofuran* OR PCDD* OR dibenzofuran* OR tetrachlorodibenzo-p-dioxin*) OR TI=(benzofuran* OR dioxin* OR polychlorodibenzo-4-dioxin* OR polychlorinated dibenzodioxin* OR polychlorinated dibenzofuran* OR PCDD* OR dibenzofuran* OR tetrachlorodibenzo-p-dioxin*)

MC=(tetrachlorodibenzodioxin* OR TCDD* OR furan* OR hexachlorobenzene OR polychlorinated biphenyl* OR PAH* OR polycyclic aromatic hydrocarbon* OR volatile organic compound* OR heavy metal* OR lead OR chromium OR cadmium OR mercury) OR DE=(tetrachlorodibenzodioxin* OR TCDD* OR furan* OR hexachlorobenzene OR polychlorinated biphenyl* OR PAH* OR polycyclic aromatic hydrocarbon* OR volatile organic compound* OR heavy metal* OR lead OR chromium OR cadmium OR mercury)

TS=(tetrachlorodibenzodioxin* OR TCDD* OR furan* OR hexachlorobenzene OR polychlorinated biphenyl* OR PAH* OR polycyclic aromatic hydrocarbon* OR volatile organic compound* OR heavy metal* OR lead OR chromium OR cadmium OR mercury) OR TI=(tetrachlorodibenzodioxin* OR TCDD* OR furan* OR hexachlorobenzene OR polychlorinated biphenyl* OR PAH* OR polycyclic aromatic hydrocarbon* OR volatile organic compound* OR heavy metal* OR lead OR chromium OR cadmium OR mercury)

AND

2. Incineration

MC=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*) OR DE=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*) OR TS=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*) OR TI=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*)

AND

3. Type of Measurement (or Study)

MC=(adverse effect* OR adverse* affect*) OR DE=(adverse effect* OR adverse* affect*) OR TS=(adverse effect* OR adverse* affect*) OR TI=(adverse effect* OR adverse* affect*)

MC=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study) OR DE=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study) OR TS=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study) OR TI=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study)

MC=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*) OR DE=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*) OR TS=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*) OR TI=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*)

MC=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies) OR DE=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies) OR TS=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies) OR TI=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies)

MC=(biosurveillance OR bio-surveillance OR surveillance OR body burden) OR DE=(biosurveillance OR bio-surveillance OR surveillance OR body burden) OR TS=(biosurveillance OR bio-surveillance OR surveillance OR body burden) OR TI=(biosurveillance OR bio-surveillance OR surveillance OR body burden)

MC=(biomonitor* OR bio-monitor*) OR DE=(biomonitor* OR bio-monitor*) OR TS=(biomonitor* OR bio-monitor*) OR TI=(biomonitor* OR bio-monitor*)

Search run 1Oct2008

# 19	229	#18 OR #16 OR #15 OR #14 OR #13 OR #12 Databases=PREVIEWS Timespan=All Years
# 18	31	#17 AND #6 Databases=PREVIEWS Timespan=All Years
# 17	3,910	MC=(biomonitor* OR bio-monitor*) OR DE=(biomonitor* OR bio-monitor*) OR TS=(biomonitor* OR bio-monitor*) OR TI=(biomonitor* OR bio-monitor*) Databases=PREVIEWS Timespan=All Years
# 16	23	#11 AND #6 Databases=PREVIEWS Timespan=All Years
# 15	26	#10 AND #6 Databases=PREVIEWS Timespan=All Years
# 14	51	#9 AND #6 Databases=PREVIEWS Timespan=All Years
# 13	74	#8 AND #6 Databases=PREVIEWS Timespan=All Years
# 12	91	#7 AND #6 Databases=PREVIEWS Timespan=All Years
# 11	34,274	MC=(biosurveillance OR bio-surveillance OR surveillance OR body burden) OR DE=(biosurveillance OR bio-surveillance OR surveillance OR body burden) OR TS=(biosurveillance OR bio-surveillance OR surveillance OR body burden) OR TI=(biosurveillance OR bio-surveillance OR surveillance OR body burden) Databases=PREVIEWS Timespan=All Years
#	50,651	MC=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies) OR

10		DE=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies) OR TS=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies) OR TI=(epidemiologic* method* OR epidemiologic* study OR epidemiologic* studies) Databases=PREVIEWS Timespan=All Years
# 9	>100,000	MC=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*) OR DE=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*) OR TS=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*) OR TI=(follow up studies OR follow up trial* OR followup study OR followup studies OR followup trial*) Databases=PREVIEWS Timespan=All Years
# 8	>100,000	MC=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study) OR DE=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study) OR TS=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study) OR TI=(cohort* OR prospective study OR prospective studies OR prospective trial* OR longitudinal study OR longitudinal studies OR longitudinal trial* OR follow up study) Databases=PREVIEWS Timespan=All Years
# 7	>100,000	MC=(adverse effect* OR adverse* affect*) OR DE=(adverse effect* OR adverse* affect*) OR TS=(adverse effect* OR adverse* affect*) OR TI=(adverse effect* OR adverse* affect*) Databases=PREVIEWS Timespan=All Years
# 6	5,039	#5 AND #4 Databases=PREVIEWS Timespan=All Years
# 5	15,075	MC=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*) OR DE=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*) OR TS=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*) OR TI=(energy from waste OR EFW OR incinerat* OR thermal destruction OR thermal treatment*) Databases=PREVIEWS Timespan=All Years
# 4	>100,000	#3 OR #2 OR #1 Databases=PREVIEWS Timespan=All Years
# 3	>100,000	TS=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*) OR TI=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*) Databases=PREVIEWS Timespan=All Years
# 2	25,174	MC=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*) OR DE=(air pollutant* OR environmental pollutant* OR soil pollutant* OR water pollutant* OR air pollution OR environmental pollution OR soil pollution OR water pollution OR air quality OR gas* emission*) Databases=PREVIEWS Timespan=All Years
# 1	>100,000	MC=(exposur* OR exposed) OR DE=(exposur* OR exposed) OR TS=(exposur* OR exposed) OR TI=(exposur* OR exposed) Databases=PREVIEWS Timespan=All Years

APPENDIX B

External Contact Standard Emails and Questionnaires

Initial Form Email for Making External Contacts

SUBJECT: International Review of Environmental Surveillance Practices

Dear Mr./Mrs./Dr. [INSERT NAME HERE]

Jacques Whitford Limited, an internationally recognized environmental consulting firm, is conducting a review of international environmental surveillance practices in the energy-from-waste industry. This review, led by Dr. Chris Ollson, has been initiated by the proposed construction of an energy-from-waste facility in southern Ontario, Canada.

Specifically, we are interested in current environmental surveillance activities conducted in your area and local regulations governing environmental surveillance activities in the energy-from-waste industry, if such practices/regulations exist at all. Environmental surveillance, by our working definition, can include but is not limited to activities surrounding the scope of environmental monitoring, human biomonitoring, health surveys and health studies.

Based on (your association with [INSERT ORGANIZATION HERE] / your past experience as demonstrated via [INSERT EXAMPLE OF PAST EXPERIENCE HERE]), we have identified you as an individual who may possess useful knowledge on the subject or who may have contacts within industry or government that would be helpful in this process. We would like to provide you with a brief questionnaire which outlines in detail the information we are seeking. You are not required to provide written answers to this questionnaire – it is merely an advanced notice of the scope of information we are seeking. We would like to follow up on this questionnaire with you in an over-the-phone interview, lasting approximately [INSERT TIME HERE], scheduled at a time that is convenient for you. During the interview, your responses would be documented, and subsequently sent back to you to ensure that we have accurately captured the information you have provided.

We thank you in advance for your time, and appreciate any assistance you could provide us in completing this review.

Sincerely,

[INSERT NAME HERE]

Jacques Whitford Limited

Follow-Up Form Email for Making External Contacts

SUBJECT: Follow-Up - International Review of Environmental Surveillance Practices

Dear Mr./Mrs./Dr. [INSERT NAME HERE]

Further to our initial email, sent on [INSERT DATE HERE], we have identified you as an individual who may possess useful knowledge on the subject of environmental surveillance or who may have contacts within industry and government on the topic. Please find a copy of our initial email below.

We would like to provide you with a brief questionnaire which outlines in detail the information we are seeking. We would then like to follow up on this questionnaire with an over-the-phone interview, lasting approximately [INSERT TIME HERE], scheduled at a time that is convenient for you.

We would appreciate any assistance or knowledge that you can provide us on this topic and thank you in advance for your time,

Sincerely,

[INSERT NAME HERE]

Jacques Whitford Limited

Questionnaire Form Email for Making External Contacts

SUBJECT: Questionnaire - International Review of Environmental Surveillance Practices

Dear Mr./Mrs./Dr. [INSERT NAME HERE]

Thank you for your response and for your assistance in this matter. As outlined, please find attached a short questionnaire outlining the nature of the information we are seeking in our review. We do not require a written response to this questionnaire.

We would like to follow up on this questionnaire with an over-the-phone interview, lasting approximately [INSERT TIME HERE], scheduled at a time that is convenient for you. Please forward us a selection of 2-3 local times that you will be available and a phone number at which we can reach you. We will confirm the time and call you to conduct the interview.

We thank you in advance for your time and assistance,

Sincerely,

[INSERT NAME HERE]

Jacques Whitford Limited

Questionnaire for Environmental and/or Human Health Surveillance Researchers

General Questions

1. How long have you been involved in environmental and/or human health surveillance programs?

Government

To your knowledge,

2. At what level of government are municipal waste incinerators (MWIs) regulated in your country? What branch/department of the government is responsible for MWI regulations?
3. Are environmental surveillance programs a regulatory requirement for MWIs in your country?
4. If yes, what components are required to form a part of such environmental surveillance programs?

Personal Research Activities

5. Who are the stakeholders in your surveillance programs (i.e. government, industry, etc.)?
6. What is the general scope of your surveillance activities?
7. Have all your results been published in the primary literature, and if not, what information on unpublished studies can you provide us?
8. Do you follow any particular best practices and if so, have these been publicly documented or published?
9. What have been the outcomes of your studies? Have they provided useful, measurable results?

Other Activities

10. Are you aware of any further environmental surveillance programs in your country, or in other countries, initiated by the operation of incinerators? If so, can you elaborate on them or provide contact information for someone more familiar with them?
11. Do know the approximate or range of costs on an annual basis to conduct these programs?

[EUROPE] – Are you familiar with the European Union Human Biomonitoring Network and Pilot Project Activities? If yes, are you involved in it and if so, what is your involvement? Can you provide any details on the goals/logistics of the program?

Questionnaire for Incinerator Operators

General Questions

1. How long have you been working for/at the municipal waste incinerator (MWI) in question?
2. What is your operational role within the MWI?
3. Can you provide a general overview of the MWI (i.e. capacity, etc.)?

Government

4. To your knowledge, at what level of government is the MWI regulated in your country? What branch/department of the government is responsible for MWI regulations?

Environmental Surveillance

5. Does the MWI conduct an environmental surveillance program, and if so, is it a voluntary activity or a regulatory requirement? If not, why?
6. If such a program exists, what are the components of this program? How long has this program been in operation and for how long will it continue?
7. If Human Biomonitoring (HBM) is a component of the program, is this voluntary or a regulatory requirement?
8. Is the program conducted by MWI employees, government or is it outsourced? Can you provide contact information for the individuals conducting the program?
9. What have been the results of the program to date?
10. Have the results of the program influenced the operation of the incinerator in any measurable way?
11. Would you be able to share the annual costs to conduct your program?
12. Are you aware of any changes being contemplated in your country in relation to environmental surveillance and EFW facilities?
13. Do you believe that the environmental surveillance programs that are currently in place are adequate to ensure the protection of public health and the environment? If not, how could they be improved?

Questionnaire for Government Contacts

General Questions

1. Can you describe the general governmental structure of your country?
2. What is your role within the government?

Municipal Waste Incinerators (MWIs)

3. At what level of government are municipal waste incinerators (MWIs) regulated in your country? What branch/department of the government is responsible for MWI regulations?
4. Are there specific regulations/legislation governing MWIs? When were these implemented?
5. Are environmental surveillance programs a regulatory requirement for MWIs in your country? If not, why?
6. If yes, is Human Biomonitoring (HBM) required to form a part of such environmental surveillance programs? If not, why?
7. If yes, is environmental monitoring required to form a part of such environmental surveillance programs? If not, why?
8. Can you provide us with the regulations or government documents that mandate the programs?
9. Do know the approximate or range of costs on an annual basis to conduct these programs?
10. Are there any changes being contemplated in your country in relation to environmental surveillance and EFW facilities?
11. Do you believe that the environmental surveillance programs that are currently in place are adequate to ensure the protection of public health and the environment? If not, how could they be improved?

Environmental Surveillance

12. If HBM is a requirement for MWIs, what are the specific requirements regarding the conduct of such a program? Have these been publicly documented or published?
13. Does the government conduct HBM in general, not necessarily associated with MWIs, but perhaps as a national health measure, for example? What branch/department of the government would be responsible for this type of activity?

APPENDIX C

Tier 1 Contacts

TABLE C.1 - MEMBERS OF THE EUROPEAN HUMAN BIOMONITORING IMPLEMENTATION GROUP (EUROPEAN HUMAN BIOMONITORING, 2008)

Country	Member Name	Affiliation	Email
European Union	Birgit Van Tongelen	European Commission DG Environment	birgit.van-tongelen@cec.eu.int
Austria	Philip Hohenblum	Austrian Federal Environment Agency	philipp.hohenblum@umweltbundesamt.at
Belgium	Ludwine Casteleyn	University of Leuven	ludwine.casteleyn@med.kuleuven.be
Belgium	Greet Schoeters	Flemish Centre of Environment and Health	greet.schoeters@vito.be
Belgium	Roel Smolders	Flemish Centre of Environment and Health	roel.smolders@vito.be
Croatia	Aleksandra Fucic	Institute for Medical Research and Occupational Health	afucic@imi.hr
Cyprus	Stella Canna-Michaelidou	State General Laboratory, Ministry of Health	stellacm@spidernet.com.cy
Czech Republic	Milena Cerna	National Institute of Public Health	mcerna@szu.cz
Denmark	Lisbeth Knudsen	Institute of Public Health, University of Copenhagen	l.knudsen@pubhealth.ku.dk
Estonia	Toomas Viedebaum	National Institute for Health Development	Toomas.veidebaum@tai.ee
Finland	Ari Hirvonen	Finnish Institute of Occupational Health	Ari.Hirvonen@ttl.fi
France	Nadine Frery	INVS, National Institute of Public Health Surveillance	n.frery@invs.sante.fr
Germany	Reinhard Joas	BiPRO GmbH	reinhard.joas@bipro.de
Germany	Marike Kolossa-Gehring	Federal Environmental Agency	marike.kolossa@uba.de
Greece	Maria Botsivali	National Hellenic Research Foundation	mbotsi@eie.gr
Greece	Soterius Kyrtopoulos	National Hellenic Research Foundation	skyrt@eie.gr
Italy	Carlo Sala	Regional Agency for Environmental Protection	c.sala@arpalombardia.it
Italy	Elena De Felip	National Institute of Health	defelip@iss.it
Luxembourg	Maryse Lehners	International Baby Food Action Network – IBFAN	maryse.lehners@education.lu
Netherlands	Louis Bloemen	Exponent Health Science	lbloemen@exponent.com
Netherlands	Peter Boogaard	Shell Health Services	Peter.Boogaard@shell.com
Netherlands	Gavin Ten Tusscher	Emma Children's Hospital Academic Medical Centre	g.w.tentusscher@amc.uva.nl g.w.tentusscher@planet.nl
Netherlands	Joop Van Wijnen	Eurocities, Amsterdam	jvwijnen@gggd.amsterdam.nl
Poland	Marek Jakubowski	Institute of Occupational Medicine, WHO Collaborating Centre	majakub@imp.lodz.pl
Portugal	Fatima Reis	Institute of Preventative Medicine, Faculty of Medicine, University of Lisbon	mfreis@fm.ul.pt
Slovakia	Eleonora Fabianova	Regional Institute / Authority of Public Health	fabianova@szubb.sk
Spain	Marisa Rebagliato	Department of Public Health, Miguel Hernandez University	rebagli@umh.es
Sweden	Marika Berglund	Institute of Environmental Medicine	marika.berglund@imm.ki.se
United Kingdom	Len Levy	University of Leicester	lsl1@leicester.ac.uk
United Kingdom	Ovnair Sepai	Health Protection Agency	ovnair.sepai@hpa.org.uk

TABLE C.2 - LIST OF GOVERNMENTAL REPRESENTATIVES RESPONSIBLE FOR HUMAN BIOMONITORING IN THE FIELD OF ENVIRONMENT AND HEALTH (EUROPEAN HUMAN BIOMONITORING, 2005)

Country	Environment Ministry	Health Ministry
BELGIUM	Dominique Aerts Ministry of the Flemish Community, Environment, Nature, Land and Water management (AMINAL) *Contact Details to be Determined* Pierre Biot Service Public Fédéral Santè Public, Sécurité de la chaîne alimantaire et Environment, DG Environment EUROSTATION, Bloc 2 ☏ 02 524 96 16 Pierre.biot@health.fgov.be	Dirk Wildemeersch Flemish Health Inspection *Contact Details to be Determined*
CZECH REPUBLIC		Michael Vit Ministry of Health *Contact Details to be Determined*
DENMARK	Lars Fock Danish Environmental Protection Agency ☏ 32 66 01 0 lfo@mst.dk	Lis Keiding, National Board of Health, ☏ 72 22 77 76 lke@sst.dk
GERMANY	Eva Dressler Federal Ministry for the Environment, Nature Conservation and Nuclear Safety ☏ +49-228-3052725 eva.dressler@bmu.bund.de	
IRELAND	Catherine Bannon ☏ 888 2 880	Mr. Brendan Murphy Assistant Principal Officer Environment Health Unit Department of Health and Children Brendan_murphy@health.irlgov.ie
ITALY	Giuliana Gasparrini, Gasparrini.giuliana@minambiente.it	Donato Greco d.greco@sanita.it
LITHUANIA		Natalija Sliachtic Hygiene Chemist, Environment and Health Division State Environmental Health Centre Ministry of Health ☏ +370 5 2360481 slechtin@takas.lt
THE NETHERLANDS	Julie Tham Ministery of Housing Spactial Planning and Environment Julie.tham@minvrom.nl ☏ +31 70 3392719 Perm Repr: Birte-van.elk@minbuza.nl ☏ 02 6791668	Ronald Mooij Ministery of Health, Welfare and Sports r.mooij@minvws.nl
PORTUGAL	Sílvia Saldanha Instituto do Ambiente ☏ +351 214728336 silvia.saldanha@iambiente.pt	Cesaltina Maria Correia Ramos Direcção Geral da Saúde ☏+ 351 218430587 Cramos@dgsaude.min-saude.pt
SWEDEN	Maria Åhs Ministry of Sustainable Development ☏ +46 8 405 47 81 maria.ahs@sustainable.ministry.se	Ann Thuvander The National Board of Health and Welfare ☏ +46 8 55 55 31 24 ann.thuvander@socialstyrelsen.se
UK		Simon H Dyer Policy Co-ordination Manager HP - Toxicology and Radiation Health Department simon.dyer@dh.gsi.gov.uk

TABLE C.3 - LIST OF CONTACTS OBTAINED FROM REGIONAL MUNICIPALITY ENERGY FROM WASTE DELEGATION TO EUROPE, JULY 2007

Country	Facility/Association	Contact Information
Denmark	Nordforbraending EFW Facility	*General Facility:* ☏ +45 16 05 00 nordf@nordf.dk
Germany	German EFW Association, ITAD	Carsten Spohn Managing Director ☏ +49 (0)931 / 6 60 58 52 spohn@itad.de
Italy	VESTA Refuse Derived Fuel and EFW Facility, operated by Idecom and Ecoprogetto Venezia	Francesca Faraon Idecom ☏ +041 4265500 francesca@idecom.it Gianni Teardo Ecoprogretto Venezia ☏ +041 5477207 teardo@ecoprogettovenezia.it
Italy	ASM Brescia EFW Facility, Brescia	Lorenzo Zaniboni Director (+030 3553 200 lzaniboni@asm.it
Italy	AMSA Silla 2 EFW Facility, Milan	Domenico Lunghi (+39 02 27298877 domenico.lunghi@amsa.it Giuseppe Sgorbati Director, Provincial Department of Milan Regional Agency for the Protection of the Environment, Lombardia (+39 02 74872204 g.sgorbati@arpalombardia.it
Sweden	SYSAV EFW Facility, Malmö	Håkan Rylander CEO, SYSAV (+46 40-635 18 01 hakan.rylander@sysav.se Jonas Eek Manager, Energy Department (+46 40-635 18 51 jonas.eek@sysav.se
Switzerland	Hagenholz EFW Facility, Zurich	General Facility: (+41 0 1 645 7777 Contact: Oswald Looser

TABLE C.4 – PRELIMINARY LIST OF CANADIAN FEDERAL AND PROVINCIAL REGULATORY CONTACTS

Level of Government	Environment Ministry	Health Ministry
Federal	N/A	*Health Canada* *Canadian Health Measures Survey*
Ontario	MOE	*MOE*
British Columbia	MOE	MOE

APPENDIX I

Study Team Curriculum Vitae

A multidisciplinary team of professionals was assembled to tackle this unique study question. A brief cameo of each member and their role is provided below.

Dr. Christopher Ollson – Study Team Director

Dr. Ollson is Jacques Whitford's National Director of Environmental Health Sciences and is located within the Burlington office. He is recognized by the Ontario Ministry of the Environment as a Qualified Person Risk Assessment under Ontario Regulation 153/04 and as a Qualified Toxicologist through the Air Standards Development Branch. Throughout his career, Dr. Ollson has led numerous multidisciplinary environmental health assessments and facilitated community consultation and risk communication for both industry and government agencies. Stakeholder engagement ensured that communities were part of the decision-making process with regards to issues surrounding airborne, soil and water contaminant emissions, or public health concerns associated with industrial facilities or contaminated site remediation.

Dr. Ollson has been involved in some of Canada's largest and most complex risk assessment and environmental assessment projects. These include the Human Health and Ecological Risk Assessment in support of the Environmental Assessment that was conducted for the proposed new Shell Canada refinery in Sarnia; Environmental Site Assessment of Herbicide Application at CFB Gagetown, NB; the proposed Bennett Thermal Oxidation Facility for disposal of hydrocarbon impacted soil in Belledune, NB; the Catalyst Pulp and Paper baseline airshed health assessment in Crofton, BC; Enbridge Gateway Project in Alberta and BC; the Sydney Tar Ponds proposed incinerator remediation facility in Cape Breton, NS; Petro-Canada's Sturgeon Upgrader; Syneco's Northern Lights Project and the INCO refinery, Port Colborne Community Based Risk Assessment in Port Colborne, ON.

Most recently Dr. Ollson was the lead author in the development of a Framework for Public Health Officials to Integrate Health Impact Assessment Considerations in Municipal Project Undertakings for the City of Toronto. He is also the Senior Project Lead for the Site Specific Risk Assessment to be conducted for the Durham/York Residual Waste environmental assessment.

Dr. Christofer Balram –Subject Matter Expert and Internal Study Review

Dr. Christofer Balram held several senior positions in the New Brunswick Public Service during the period 1986 - 2008. He was the Provincial Epidemiologist and the Director of the New Brunswick Provincial Epidemiology Service. He also held other senior positions concurrently - Director of Health Promotion and Disease Prevention, Director of the New Brunswick Cancer Registry and the Director of the New Brunswick Serum Depot. Before joining the Public Service he held full-time medical faculty appointments at Memorial University of Newfoundland and Dalhousie University in Nova Scotia. He is a certified member of the American College of Epidemiology. He is a graduate of Memorial University, holds a BA in Sociology and Anthropology, BSc in Biochemistry, MSc in Medicine and a PhD in Medicine. He also holds an MD in Alternative Medicine from Calcutta, India.

Dr Balram has worked on numerous Health Studies in the capacity of Lead Investigator and/or Senior Professional in the Department of Health responsible for the conduct of these studies. They include The Greater Belledune Area Health Study that evaluated the impact of the Belledune Lead Smelter on the health of residents living in the area; the McAdam Health Study which investigated high cancer rates in the community, the Town of Newcastle Health Study which evaluated the impact of chemicals in the environment on the health of residents and Blood Lead levels in Children living in Saint John, New Brunswick. He was also a member of the CFB Gagetown Advisory Panel that advised the Federal Government on the impact of Agent Orange on the health of workers and residents. Dr. Balram has written many reports and scientific papers, in addition to making numerous scientific presentations to health professionals and the public.

Kaitryn Campbell, BAH, BEd, MLIS – Health Sciences Information Specialist / Librarian

Ms. Campbell has been a Health Sciences Information Specialist for seven years. Since graduating with her Masters of Library and Information Science from the University of Western Ontario in 2001 she has held positions at the Children's Hospital of Eastern Ontario (CHEO), the Ottawa Hospital, the Canadian Agency for Drugs and Technologies in Health (CADTH) and is currently employed by the Programs for Assessment of Technology in Health (PATH) research group at McMaster University. Her expertise lies in the development and conduct of literature search strategies and information retrieval for systematic reviews related to topics in the health sciences.

Mathieu Morin, M.Env.Sc., EIT – Study Team Member

Mathieu Morin is with the Environmental Health Sciences group at Jacques Whitford Limited. He holds a Bachelor's of Science in Engineering degree in Engineering Chemistry from Queen's University and a Masters of Environmental Science Degree from the University of Toronto. His experiences and background have provided him the opportunity to gain significant knowledge in the fields of environmental and health sciences. Specific projects completed at the University of Toronto include a theoretical human health and ecological risk assessment on the application of DDT for the treatment of malaria, as well as thorough scientific literature reviews on PAH contamination in soil, and radon contamination in groundwater. Since joining Jacques Whitford, Mr. Morin has had the opportunity to contribute to a number of projects prior to the current review, including several human health and ecological risk assessments for contaminated sites, as well as the development of a corporate policy-based influenza pandemic plan.

Sarah Henderson, B.A.(H.) – Study Team Member

Sarah Henderson is a scientist with the Environmental Health Sciences group at Jacques Whitford Limited. Her work at Jacques Whitford is concentrated on this systematic review of literature on the international environmental monitoring best practices for incinerators. Ms. Henderson holds a Bachelor of Arts (Honours) degree in Geography and Environmental Studies from McMaster University. While at McMaster University, she gained useful knowledge in environmental impact assessments as well as environment and health. Ms. Henderson also had the opportunity to assist with full-scale systematic literature reviews while employed at the Programs for Assessment of Technology in Health research group (PATH). As a result of her time at PATH, she has gained extensive knowledge in literature retrieval, literature screening and bibliographic software applications.

APPENDIX J

Occupational Monitoring Results

Human Biomonitoring of Facility Employees

Twenty-six (26) articles on the human biomonitoring of facility employees were identified. Of these 26 articles, only 11 were found to satisfy the requirements of the quality assessment framework. As discussed with respect to the human biomonitoring of residents, the two most common reasons for the failure of an article to meet the requirements of the quality assessment framework were the distinct lack of a control group or baseline for comparison of the results and the lack of lifestyle and personal factor questionnaire results. The 11 articles that passed the quality assessment framework are further discussed below.

Impact of a Hazardous Waste Incinerator on Facility Employees in Tarragona, Spain - (Domingo et al., 2001; Schuhmacher et al., 2002a; Agramunt et al., 2003; Mari et al., 2007; Mari et al., 2008b)
Funding Source: Catalonian Government

Alongside the human biomonitoring of residents, J.L. Domingo and his research associates at the Laboratory of Toxicology and Environmental Health also conducted human biomonitoring of workers at the same hazardous waste incinerator as described in Section 3.4.2.2. Five papers were published between 2001 and 2008, outlining the baseline measurements and four subsequent follow-up studies at 1, 3, 6, and 8 years after incineration operations commenced.

Each study examined levels of metals (arsenic, beryllium, cadmium, chromium, lead, manganese, mercury, nickel and vanadium) and organic substances (PCDD/Fs, PCBs, HCB, DCPs, TCPs, PCP and 1-HP) in blood and urine of 20-30 workers, both male and female, representing different employment groups within the facility. Examples of occupations include incinerator operators, furnace or boiler maintenance workers, laboratory workers, and administration workers. With the exception of the baseline, samples were pooled into 6 samples (4 representing plant workers, 1 representing each of laboratory and administrative workers). All participants volunteered for the study. A questionnaire was administered to all participants regarding personal and lifestyle factors.

Though some individual increases were observed in individual study events, over the course of the 8 year study, the authors have not identified any notable increases in the chemicals measured. The authors did observe a significant reduction in some measures such as PCDD/F, PCB 28, PCB 52 and PCB 101 concentrations in the blood levels of plant workers. The authors conclude their most recent paper by stating that "the results of the present study performed after 8 years of regular operations in the HWI (Hazardous Waste Incinerator) do not show evident signs of occupational exposure to a

Relevance to Current Study

This study shows that if desired, a human biomonitoring program focused on facility employees can provide measurable results, akin to the human biomonitoring programs surrounding residents previously described. However, as was often the case there, within this study the results do not indicate that facility employees are in a position of occupational exposure.

number of metals and organic substances. Most current concentrations are either similar or lower than the respective baseline levels" (Mari et al., 2008b).

PCDD/F Concentrations in Serum Samples of Workers at Continuously and Intermittently Burning Municipal Waste Incinerators in Japan - (Kumagai et al., 2000; Kumagai et al., 2002)

Funding Source: Grant in Aid for Scientific Research

Kumagai et al. of the Osaka Prefectural Institute of Public Health published two (2) papers on PCDD/F monitoring in serum of workers at municipal waste incinerators in Japan. Each study comprised of workers at 3 municipal waste incinerators – continuously burning incinerators in one case, and intermittently burning incinerators in the other. A cross-sectional study design was employed in each case.

The first study (continuously burning facilities) compared PCDD/F concentrations in 30 facility workers (10 at each of three facilities) to concentrations in 30 workers at municipal government or labor union offices in the vicinity of the three facilities (Kumagai et al., 2000). Incinerator workers had a mean employment duration of 22-24.5 years, and controls had no known prior occupational exposure to PCDD/Fs. Incinerator workers typically operated, inspected and repaired the incinerators. Controls consisted of clerical workers, drivers, a cook and a doctor. Participant age ranged from 40 to 59 for the study group and from 38-59 for the control group. Questionnaires were administered to the workers on personal and lifestyle factors that could aid in the identification of confounding factors.

The authors identified no significant difference between PCDD/F TEQ levels in the study and control groups. Some differences existed at the individual congener level, in particular 1,2,3,4,6,7,8-HpCDF, which was significantly higher in all three study groups compared to the control groups. The authors hypothesized that this result indicates that workers inhaled dust containing PCDD/F in their employment. They note that workers wear dust or airline masks during repair work but complain of nostril pollution after completion of the work, and during normal facility operation, wear no respiratory protection.

The second study (intermittently burning facilities) was similar in methodology to the first. 20 workers at three facilities were compared to 20 municipal government employees in the same vicinity as the facilities (Kumagai et al., 2002). Incinerator workers had a mean employment duration of 10-16 years and controls had no known prior occupational exposure to PCDD/Fs. Incinerator workers typically operated, inspected and repaired the incinerators. The control group consisted of clerical workers. Participant age ranged from 24 to 59 for the study group and from 27-58 for the control group.

Relevance to Current Study

This study highlights the importance of using appropriate personal protective equipment in situations that could lead to occupational exposure. A facility health and safety plan, along with the appropriate equipment, could have alleviated the necessity to conduct such a study.

Questionnaires were administered to the workers on personal and lifestyle factors that could aid in the identification of confounding factors.

This second study was undertaken as emissions levels in Japan have shown that intermittent facilities tend to emit larger quantities of PCDD/Fs than continuously operating facilities. The conclusions of this study were identical to the previously described study. The authors also conducted sampling of dust at the facility and further confirmed their hypothesis by determining that 1,2,3,4,6,7,8-HpCDF was one of the dominant PCDD/F congeners in dust at the facility. Although the employees wore dust masks, the authors note that employees complained of nostril pollution after performing cleaning work, hypothesized to be caused by leaks in the dust masks.

***Dioxin Concentrations in the Blood of Workers at Municipal Waste Incinerators* –** (Schecter et al., 1995)
Funding Source: Not specified

The authors of this study were interested in determining whether or not an occupational exposure to dioxins existed for employees in Germany of both an older incinerator without adequate pollution controls and a newer incinerator built with modern pollution controls. To address the issue, the authors used a cross-sectional study design. The study group consisted of 10 employees from the older facility and 11 employees from the newer facility. Information provided by the employer was used to determine the sociodemographic and occupational characteristics of the employees. Employees at the older facility had an employment duration of 2-14 years in the industry, and were all male. Employees deemed to have the highest potential exposure were those whose responsibilities included the inspection and repair of the oven filters (3 of the 10 employees). This work was originally performed without personal protective equipment, and increasing protective equipment use was documented over time. Employees at the newer facility were matched for age, sex and race, and had an employment duration ranging from 14-24 years in the industry. Eight (8) of the 11 workers at the newer facility had similar job classifications to those most highly exposed at the older facility. Results were compared to 25 individuals from the general population, also matched for age, sex and race. Dioxin concentrations in blood samples were determined by gas chromatography/mass spectrometry at a laboratory certified by the World Health Organization.

The major results reported by the authors of this study were that mean concentrations of multiple dioxin congeners as well as total PCDD/F concentrations by weight were significantly higher in employees of the older incineration facility when compared to the control group. No such significant differences were found when comparing employees

Relevance to Current Study

The study provides a useful commentary on the difficulty in establishing a causal link between elevated chemical levels in the human body and the source of exposure. It also highlights the hypothesis that employees are older, less modern incineration facilities are more susceptible to occupation exposure than employees are newer facilities with more modern pollution control systems.

at the newer incineration facility to the control group. No significant differences were found with respect to the toxic equivalent for either the employees at the older and newer facilities in reference to the control group. Although the authors did not definitively conclude that the difference in pollution control technology was responsible for the differences observed between the two study groups, as other potential sources of exposure such as dietary intake were not considered, the results are certainly suggestive. The differences could not be attributed to age or job classifications which were considered as potential confounding factors in the study.

Appropriate statistical tests were used to analyze the data. Weaknesses of the study include the omission of some detailed information regarding the selection criteria of the employees which would assist in further eliminating bias.

Arsenic Burden Survey among Refuse Incinerator Workers - (Chao & Hwang, 2005)
Funding Source: Not specified

The authors sought to determine the arsenic body burdern of incinerator employees at a facility in Taiwan, which has been operating since 1995. 122 facility employees were included in the study. Results were compared to a control group of 122 residents, matched for age and sex, living for at least 6 months in the vicinity of the facility. Employees were split into 3 groups, those with direct, indirect and no exposure to combustion pollutants. Employees facing direct exposure included those involved in the direct operation of the incinerator and those involved in the ash disposal process. These employees wore activated carbon facemasks and gloves during the working shift. Indirect exposure employees included maintenance personnel, electricians, management executives and safety inspectors. Employees with no contact include guards and administration executives responsible for document management and purchasing, among other things. A self-administered questionnaire was provided to participants regarding lifestyle and personal factors.

The authors observed statistically significant differences in arsenic body burden among the three groups. Those with direct exposure to combustion pollutants were observed to have a significantly lower blood arsenic concentration than those with indirect or no contact. No significant differences were observed with respect to urine concentrations. As well, no correlation was observed between urine and blood arsenic concentrations. The authors also sampled downstream rivers and drinking water arsenic concentrations and found no elevated concentrations. All three groups of workers were found to have significantly higher body burdens of arsenic when compared to the control group of nearby residents. The authors hypothesized that the results were due to the use of personal protective

Relevance to Current Study

This study further highlights the importance of adequate health and safety programs within the workplace, as those employees wearing personal protective equipment were observed to have the lowest arsenic body burdens among the three groups. The study also highlights the importance of choosing appropriate measurements for the study, as arsenic concentrations in blood and urine provided different results which if considered alone, would likely lead to different conclusions.

equipment. Employees with direct exposure to combustion pollutants were the only employees required to wear personal protective equipment (in this case, face masks and gloves). Other causes such as proximity of residence to the incinerator, ash concentrations, emissions concentrations, and dietary intake were considered but were not found to account for the differences.

Exposure Assessment of PCDD/Fs in Temporary Municipal Waste Incinerator Workers Before and After Annual Maintenance - (Shih et al., 2006)
Funding Source: Council of Labour Affairs in Taiwan

The authors assessed the change in PCDD/F levels in the serum of 35 temporary incinerator maintenance employees, both prior to commencement of cleaning operations and one month after the completion of such operations, at 4 municipal waste incinerators in Taiwan. Sixteen (16) of the 35 workers had no previous incinerator cleaning experience, and all employees wore dust masks when working at the facility, although the authors note "there was no proof that the masks protected them from inhaling pollutants inside the plant". Information regarding personal and lifestyle factors was obtained through the use of a participant questionnaire, which assisted in the identification of confounding factors. All but one employee were male, and participants had a mean age of 41.8 years.

The authors identified a statistically significant increase in the PCDD/F blood levels one month after cleaning operations. The authors further broke down the results based on previous experience and found a more significant increase in employees with no previous incinerator cleaning experience. As well, both before and after the cleaning operations, those employees with previous cleaning experience carried higher body burdens of PCDD/F than those with no experience. The authors acknowledged that the relatively small sample size of the study limits the ability to make definitive conclusions, but highlight that the study shows the need to pay closer attention to occupational health hazards.

Relevance to Current Study

This study further highlights the need for appropriate health and safety practices at incineration facilities, along with adequate personal protective equipment.

Polybrominated Diphenyl Ethers in Blood from Korean Incinerator Workers and General Population - (Lee et al., 2007)
Funding Source: Korean Research Foundation

The authors sought to determine whether incinerator employees in Korea were occupationally exposed to polybrominated diphenyl ethers (PBDEs). To achieve this end, a cross-sectional study design was adopted. PBDEs were analyzed in the blood of 30 workers from three (3) municipal waste incinerators and one industrial waste incinerator, 51 residents living within 1 km of a facility and 11 controls living 6-20 km from the facility. Workers had been employed between 1 and 180 months (15 years) in various positions ranging from office workers to operators and engineers. A self-administered questionnaire on personal and lifestyle factors was provided to all participants.

> ***Relevance to Current Study***
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> This study shows that human biomonitoring can be done on a number of chemicals, including those less frequently done in other studies, such as PBDE in the current case. However, the results of this study do not indicate occupational exposure as a result of the combustion process. The study does, however, highlight the need to consider all possible sources of occupational exposure, rather than focusing on the combustion area.

The authors found that incinerator workers had slightly higher concentrations of PBDEs than residents and controls, but that the differences were not significant in comparison to other identified similar studies. The authors also found that all three groups displayed similar congener profiles in their blood, indicating that "incinerator workers do not have significant exposure to PBDEs in the workplace". The authors hypothesized that the differences are more likely due to low level exposure from the incoming waste itself rather than the incineration process since high incineration temperatures are able to significantly eliminate PBDEs in the combustion process.

Summary of Human Biomonitoring of Facility Employees

The identified studies confirm the hypothesis that incineration facility workers are expected to be subject to a higher exposure to potential pollutants than residents living in the vicinity of the facility. This occupational exposure is inherent in the nature of the work. Employees responsible for cleaning the furnace or other parts of the facility are the most susceptible. However, the results also confirm that with proper health and safety measures, including appropriate personal protective equipment, workplace exposure to pollutants can be significantly minimized. It should be noted that where the authors identified any increase of chemical levels in biological media of workers, they also identified that workers either a) were not using appropriate personal protective equipment or were improperly using such equipment (Kumagai et al., 2000; Kumagai et al., 2002; Chao & Hwang, 2005; Shih et al., 2006), or b) were employed at an older facility which may not have the same level of pollution control as today's more modern facilities (Schecter et al., 1995).

Facility Ambient Air Monitoring

9 studies included in data abstraction assessed ambient air in waste incineration facilities (Almaguer & Driscoll, 1991; Tharr, 1991; Burton et al., 1992; Crandall et al., 1992; Kinnes & Bryant, 1992; Rahkonen, 1992; Esswein & Tepper, 1994; Kinnes et al., 1995; Bakoglu et al., 2004). Of these only 2 passed though the quality assessment framework. The outcomes of the remaining 7 were excluded due various quality issues (usually lack of a valid control group). The sampling methodologies were similar across all studies. The sampling of facility ambient air was frequently conducted by placing air samplers (both high-volume, and low-volume) at the breathing zone of incinerator workers. These samplers were then stationed in various locations throughout a facility. Surface wipes were also taken to assess particulate matter. Sampling locations were usually chosen by using the locations where workers were most likely to have the highest rates of contamination (i.e. furnace room and transfer room). In the instances where a control sample was used, they were taken in an area with no influence from the incinerator (i.e. a hotel room). Particulate matter and PCDD/Fs were the most commonly tested chemicals in worker ambient air studies.

PCDD/F concentrations in ambient air inside a municipal waste incinerator in Philadelphia, Pennsylvania, United States. (Crandall et al., 1992)
Funding: No Funding Discussed

In 1992 Crandall et al. assessed the chemical concentrations of PCDD/Fs in the internal ambient air of a municipal waste incinerator located in Philadelphia, Pennsylvania, USA. The study was conducted as a result of requests to NIOSH to conduct health hazard evaluations. The objective of the study was to evaluate if PCDD/F concentrations in ambient air were elevated to indicate possible occupational exposure.

Samples for PCDD/F compounds were collected using methods developed by the New York State Health Department. Four (4) ambient air samples were taken from the incinerator cleaning area, incinerator central area, Southside ash pile, and the Northside ash pile. Four (4) surface wipe samples were collected from the incinerator floor, lunchroom tabletop, change room bench and an office desktop. A control air sample was taken from a residential area not affected by incinerator emissions and a control surface wipe was taken inside a hotel. PCDD/F concentrations were analyzed using gas chromatography/high-resolution mass spectrometry.

> ***Relevance to Current Study***
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> This study is an indication that occupational exposure is possible in areas that are regularly exposed to internal incinerator emissions, in particular incinerator cleaning operations. It also indicates the need for personal protection equipment in these areas of elevated risk of exposure. This study is limited by the small sample sizes of ambient air, but is in general a good indicator of occupational exposure. A more comprehensive sampling program is needed to be able to draw strong conclusions from the research.

The highest PCDD/F airborne concentration was from a sample collected during an incinerator cleaning operation in which workers wore airline respirators. In the remaining 3 air samples, PCDD/F concentrations were found to be below the National Research Council Guidelines and therefore did not pose a high risk of occupational exposure. The highest surface sample was from the incinerator floor. This was slightly above the National Research Council Guideline and could possibly result in dermal exposure. The results of the sampling campaign indicated the need for special clothing to reduce inhalation and skin exposure to PCDD/Fs.

Workplace exposure to PCDD/Fs in ambient air in a municipal waste incineration facility in Finalnd. (Rahkonen, 1992)
Funding: Finnish Work Environmental Fund and additional financial support was received from the waste treatment plants in which the work was carried out

At the time of the study there was one (1) waste incineration plant in Finland. In a report on workplace safety in waste treatment plants odour and dust were reported to be nuisances when the personnel were interviewed. The aim of the study by Rahkonen (1992) was to determine levels of microbes, edotoxin, dust and heavy metals in the working air of two (2) waste sorting plants and one (1) incineration plant. For the purposes of this review, only the results from the waste incineration plant will be summarized.

Air samples were taken within the incinerator in the workers breathing zones at the unloading hall, bunker hall, cabin of the crane, kiln hall, basin, and central control room. Background samples of microbes and endotoxins were taken during each sampling day from an area where there was no corresponding load.

Dust and microbes at the incineration plant reached high levels during unloading and in the bunker hall. The identified bacteria in the samples did not include any potent pathogens. The author's identified that efficient dust removal systems should be installed in the unloading room and the bunker hall in order to reduce exposure. The researchers concluded that in areas where there is a higher risk of occupational exposure employees should wear proper protective equipment.

Relevance to Current Study

The research further confirms that occupational exposure is possible in areas that are exposed to internal incinerator emissions. It also provides additional evidence that personal protective equipment is essential to protect against occupational exposure.

Summary of Facility Ambient Air Studies

Facility ambient air studies further support the assumption that incinerator workers are subject to occupational exposure of chemicals associated with incinerators. Employees working in the furnace room or in areas with close proximity to the burner have the highest risk of occupational exposure. All studies recommend that workers who are in close proximity to the burner should wear respirators to reduce the likelihood of inhalation of chemicals and metals, as well as practice safe work habits (Almaguer & Driscoll, 1991; Tharr, 1991; Burton et al., 1992; Crandall et al., 1992; Kinnes & Bryant, 1992; Rahkonen, 1992; Esswein & Tepper, 1994; Kinnes et al., 1995; Bakoglu et al., 2004).